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ALUMINUM AND ALUMINUM ALLOYS FOR USE ON BOARD SHIP.

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(*Continued*)

FABRICATED ALLOYS.

Tensile strength, proportional limit and hardness of aluminum alloys are materially improved by the various fabrication processes, *i. e.*, rolling, forging, drawing, extruding, etc. Only part of this improvement is due to the elimination of the ordinary foundry defects such as blowholes, cracks, etc., and the densification by compression: the greatest part of it must be attributed to a structural change in the metal taking place

during the fabricating process. The nature of this structural change must be thoroughly understood in order to appreciate the effect of fabrication.

When subjected to strains beyond the elastic state, the crystals of a metallic structure elongate in the direction of the strain. In order to adapt themselves to the new configuration due to the forced alteration in shape, the crystals slip along gliding surfaces. This slipping similarly to the rubbing action in polishing the surface of metal creates a layer of amorphous material (material in which the crystalline structure is completely broken up) along the slip planes, which, after it has set, is hard and nonplastic and effectively resists further slip along the same planes. It furthermore furnishes a stiffening skeleton for the whole structure, so that any slip is made more difficult. In this manner, strength and hardness are raised, at the expense of ductility. The effect of the amorphous layer is, however, undirectional. It raises the elastic limit in tension, but decreases it in compression, leaving the total range of elasticity, from the limit in compression to the limit in tension not materially different from that of unstrained material.

The above explains in general the theory of strain hardening or cold working. If such "cold worked" strain hardened material is heated up beyond a certain "critical" or annealing temperature, "recrystallization" sets in, *i.e.*, the amorphous layer gradually changes back into the crystalline form and due to the greater mobility of the atoms at the higher temperature the elongated crystals break up into smaller crystals, which change back into equiaxed shape. When completely annealed, the structure therefore consists of an aggregate of equiaxed crystals, which are very small compared with those of the original material before cold working, because the crystals reborn from the amorphous mass start out with minute area and the elongated crystals, which did not change to the amorphous state, broke up in annealing. If the annealing process is unduly prolonged, these small crystals will grow in size to

the detriment of the physical properties of the material, which are largely dependent on grainsize. This tendency to crystal growth always exists in a metallic structure: at ordinary temperatures it is kept in check by the internal resistance of the structure; when the temperature is raised, this resistance is diminished and there is a stage, when the tendency to crystal growth overcomes the internal resistance. This point is reached earlier with strained materials than with unstrained ones. Temperature in excess of it will cause rapid coarsening of the grain, even during the mere gradual cooling. Cold worked material, which has been annealed at the right temperature and just long enough will have greater strength and ductility than the same material before cold working; it will have less strength and more ductility than after cold working, but its properties will not be "directional" as in cold working. Furthermore excessively strain hardened, cold worked metals, particularly if used in hot climates, exhibit a tendency to "season cracking." Even before actual fissures develop, cold-worked strain hardened material generally has less corrosion resistance than normal or annealed material, due to the electropositive character of the strained portions, especially where the degree of cold working is different for different parts of the piece.

Hot working, as exemplified for instance by forging, is a combination of strainhardening and annealing. If deforming strains beyond the elastic state are applied to the material in the hot state, a compensating annealing action is taking place, while deformation is going on. At a sufficiently high temperature, the rate of recrystallization will be as rapid as that, at which the crystals are disturbed. If the deforming action is stopped at any time, with the temperature just high enough to carry through complete recrystallization, there will be no direct signs of the application of work, except the smaller grainsize. If the temperature, at which the deforming action is carried on, is higher than just required for complete recrystallization, crystal growth will set in, resulting in lower physi-

cal properties but with true crystalline structure. If the temperature is below that required for complete recrystallization traces of cold working or strain hardening will remain in the material. The temperature and duration of exposure, which will just balance the effect of strain hardening, is of course not a constant figure; it will depend in every case on the rate of deformation and on the material. Aluminum for instance exhibits extreme sluggishness in this respect, so that prolonged exposure to a relatively high temperature is required to bring about complete recrystallization. In general it is considered good practice to carry on hot working down to a temperature below the limit, at which complete recrystallization is assured and to permit a certain degree of strain hardening in order to prevent the objectionable coarsened crystalline structure, which would result from the higher temperature.

ROLLING.

Rolling of aluminum for the purpose of manufacturing aluminum sheet differs from steel, brass and copper rolling in at least one marked essential, *i.e.*, the relatively low temperature employed for the hot work, furthermore, all of the final reduction to gauge is performed in the cold state. The size of the ingot, from which the sheet is to be rolled, depends on the width, length and thickness required in the finished sheet and is limited primarily by the size of existing rolling equipment and furthermore by the difficulty of securing sound and otherwise satisfactory ingots of greatly enlarged proportions and weight. The present maximum standard size of mill in this country for breaking down and finishing has rolls in both stands 28 inches in diameter and 84 inches long in the body. Its capacity for width of sheets is 72 to 78 inches according to length and thickness of same. Ingots up to 6 inches in thickness, weighing around three hundred pounds have been rolled on the above 28 inch $\times$ 84 inch mill. During the recent World War the A. Garrison Foundry Company of Pittsburgh furnished The Aluminum Francais for their

Chambery Plant in France an aluminum mill consisting in the main of a stand of 30 inches × 98 inches hot breaking down rolls and a stand of 30 inches × 130 inches finishing rolls. Ingots up to 1650 pounds weight have been rolled on this mill into plates up to 30 feet length and 7/100 inch thickness. This French mill is the largest one of its kind, of which positive knowledge is had, but there is good reason to believe that there are plate and sheet mills of even greater capacity in operation in Germany. Our leading manufacturers of rolling mill equipment would unhesitatingly and promptly build machinery to equal any used abroad, if commercial demand could be developed for it.

Ingots are sometimes fed into the rolls directly, when they come out of the molds, but more often and preferably they are allowed to cool down and are then preheated again before rolling. They are broken down in the hot mill and are subsequently cold slabbed before roughing and finishing, with the exception of sheets to finish heavier than No. 12 gauge, which are not slabbed but hot rolled and finished from the hot mill slabs. Ordinarily an aluminum ingot is rolled by giving it two or three passes, so that the ingot is elongated to a length sufficient to give the desired width of the slab, whereupon this resultant thick slab is turned at right angles to the original direction of rolling and cross rolled to the desired thickness. In the finishing roll, sheets to finish 20 gauge and lighter are run in "pack," while heavier sheets are run singly. This is done because it would be impossible otherwise to reduce the sheet to gauge.

Aluminum sheets are furnished in various degrees of hardness, deadsoft, intermediate tempers and hard. Deadsoft sheets are annealed after they leave the finishing mill, that is, no cold work is done on the sheet after the last anneal. Other tempers are obtained by varying the number of gauge points between the last anneal and the finishing gauge. Conventionally a certain nomenclature is used by the manufacturers to indicate the temper of the sheet. An index number ap-

pended to the base letter or figure denoting the alloy, etc., shows how many gauges the sheet was coldrolled after the last anneal. For instance, 2S0 means dead soft, 2 S sheet; 2S4 means 2S sheet, which was cold rolled 4 gauges after the last anneal.

With reference to sizes of sheet available any thickness from 0.0003 inch to about 2 inches can be furnished. The maximum width and length possible varies with each different gauge and is governed by the present equipment and the size of the ingot as brought out above.

Commercial sheet is marketed in this country, with some special exceptions, in three compositions, commercially pure aluminum, an alloy containing about 1.5 per cent manganese and in Duralumin. (Nominal composition 3.5—4.5 per cent copper, 0.2—0.75 per cent magnesium, 0.4—1.0 per cent manganese and 92 minimum aluminum.)

Pure aluminum (minimum of 99 per cent aluminum) has a very high resistance to salt water corrosion and due to its high ductility is especially suitable for severe forming processes, such as drawing, spinning, etc. Its tensile strength and hardness is lower than that of the alloys.

For instance in No. 10 B & S gauge

Dead soft commercially pure aluminum shows—

Ultimate tensile	12,800 pounds.
Elongation in 2 inches	37 per cent.
Brinnell	22, Shore Scleroscope magnifying hammer 5.

The same gauge hard shows—

Ultimate tensile	21,400 pounds.
Elongation in 2 inches	8 per cent.
Brinnell	46, Scleroscope 21.

The smaller the gauge, the higher the ultimate tensile and hardness and the lower the elongation. The Manganese alloy has about the same resistance to corrosion as the commercially pure aluminum, its tensile strength and hardness are higher, but its ductility is not as high.

In the No. 10 B. & S. gauge, dead soft the manganese alloy sheet shows—

Ultimate tensile	18,200 pounds.
Elongation in 2 inches	27 per cent.
Hardness Brinnell	32, Scleroscope 9.

The same gauge hard shows—

Ultimate tensile	30,600 pounds.
Elongation in 2 inches	5 per cent.
Hardness Brinnell	62, Scleroscope 26.

The third grade of sheet, designated as Duralumin (or as 17 S, when furnished by the Aluminum Company of America) derives its important mechanical properties from a specific heat treatment and subsequent aging.

It is most ductile in the annealed form and when cold-forming operations of any severity are to be performed the sheet should preferably be used in this state. Due to the fact that annealed articles will harden slightly during the course of time mechanical work should be done as soon as practicable after annealing. The metal is also quite ductile, although to a lesser extent than when annealed, immediately after quenching before any aging has set in and in some cases especially where for reasons of assembly (on acount of the possibility of warping during heat treatment) subsequent heat-treatment after forming is impracticable or impossible, forming operations are carried out at this stage. After cold forming the annealed sheet should be heat treated. In addition to the greater facility and wider range of operation the heat treatment after cold forming removes all traces of internal stresses, which might be left in the part if cold formed in the heat treated state and makes the material more resistant to corrosion.

The physical properties of Duralumin sheet are given below:

Ultimate tensile	Annealed (No. 24 to $^3/_8$ inch)	28,000–35,000 pounds.
	Tempered (No. 24 to $^7/_{32}$ inch)	55,000–60,000 pounds.
	($^1/_4$ to $^3/_8$ inch)	50,000–55,000 pounds.
Elongation in 2 inches		Annealed
	From as rolled	10–15 per cent.
	Tempered	18–20 per cent.
Proportional limit	Tempered	20,000 pounds.
Hardness	Annealed	48–72 Brinnell.
	Tempered	85–100 Brinnell.

Shearing strength is around 20,000–25,000 pounds for tempered material.

The strength and hardness of Duralumin sheet after tempering can be materially increased by additional cold working at the expense of its ductility but of course in this form the sheet does not lend itself to forming operation of any magnitude, furthermore its resistance to corrosion is materially reduced.

Its properties are as follows—

Ultimate tensile	60,000–75,000 pounds.
Elongation in 2 inches	3–5 per cent.
Proportional limit	May go as high as 30,000.
Hardness	100–140 Brinnell.

It can be obtained in thickness up to ¼ inch only.

In heat treatment the material should be brought gradually to 500 degrees to 510 degrees C. and held constant at this temperature for 10 to 30 minutes according to the size and number of the pieces, until all parts and sections have reached uniform temperature. Quench immediately in ordinary boiling tap water, after which the metal should be aged in boiling water for at least three hours. The interval of time between taking the metal out of the heat treating furnace and placing it in the quenching bath should be kept below ½ minute. If the metal is quenched below 485 degrees C. it will not have the properties of Duralumin. On the other hand if heated above 525 degrees C., it becomes unusable. Allowance should be made for loss of heat of the metal while being transferred from furnace to quenching bath, which may amount to 5 to 10 degrees C. Quenching in boiling water has some advantages over quenching in cold water, as it is less likely to cause distortion or cracking due to cooling stresses. However, quenching in cold water (room temperature) leaves the material in a softer and more workable condition, there is also some evidence that resistance to corrosion is slightly greater than when quenched in boiling water.

The best temperature for aging depends on the properties desired. For most purposes it will be found best to age at 100 degrees C. This treatment develops both high strength and high ductility. Higher proportional limit but lower ductility may be obtained by aging at higher temperatures. Maximum hardness is obtained by aging at temperatures above 100 degrees C. but above 140 degrees C. hardness decreases again. Heating may be done in an electric, gas, oil, or even coal fired muffle or semi-muffle furnace, provided proper temperature, control and uniformity can be assured.

A saltbath composed of molten nitrates, either sodium or potassium nitrate or a mixture of approximately equal parts of sodium nitrate and potassium nitrate may be used with good results but care should be taken to wash off all adherent salt to avoid subsequent corrosion.

Contact with an open flame damages the metal.

No scale is produced in heating Duralumin although a slight, purely superficial discoloration occurs.

It should be noted that Duralumin is softened considerably during the heating process and unless the parts are properly supported, sagging due to their own weight will occur, which will result in the finished material being more or less buckled. Duralumin is annealed at from 650–700 degrees F. If the material is heated above 700 degrees F., there is danger of slight aging effects and also of coarser grain structure.

Soaking at the annealing temperature and slow cooling are essential to obtain the softest product.

Fatigue data have lately been supplied by R. R. Moore as the result of an investigation made by the Engineering Division of the Air Service at McCook Field, Dayton, Ohio.

The test specimens were taken from ½ inch diameter rolled bars tempered and annealed in the McCook Laboratory. They were tested in a machine of the two point symmetrically loaded rotating beam type, producing reversals of stress of equal magnitude from tension to compression. The endurance limit (unlimited number of reversals) is shown to be 12,000 pounds

per square inch for the tempered material and about 10,800 pounds for the annealed material. This corresponds quite well with a statement of the Aluminum Company of America, as follows:

"The results which we have on the fatigue properties of tempered 17 S (corresponding to Duralumin) indicate that where the stressed member is called upon to operate from a given tensile stress to the same compressive stress, that the limiting value for this tensile or compressive stress is 10,000 pounds per square inch. When called upon to function at or below this value the life of the member ceases to be governed by the stress, but is determined by other factors such as flaws in the metal, machine tool marks, scratches, etc."

A table of comparison of properties of Duralumin mild and alloy steels should be of particular interest to the Naval Engineer.

	Duralumin Temperated	Mild Steel	Alloy Steel
Specific gravity	2.85	7.8	7.8
Weight pounds per cubic inch	.101	.27	0.27
Tensile strength, ultimate	55,000	55,000	125,000
Yield point	25,000	36,000	100,000
Mod. of Elasticity	10×10^6	30×10^6	30×10^6
Strength-weight factor $\frac{S}{W}$	19,250	7,050	16,000

Corrosion resistance of Duralumin is better for the tempered material than for annealed. Cold working after heat treatment will decrease the corrosion resistance.

The purity and uniformity of the material is an important factor and segregation of impurities or of normal constituents according to Horace C. Knerr is probably responsible for pitting and splitting.

The Bureau of Standards in Circular No. 76, Aluminum and its Light Alloys, reports that U profiles of Duralumin, copper, iron, aluminum alloys, pure aluminum and electron were exposed to the action of sea air on a light ship in the North Sea for three months. These sections were also riv-

eted and screwed together. Duralumin resisted these conditions better than any of the other materials and showed practically no oxidation.

Our own tests showed very favorable results for tempered Duralumin, but we do not believe that it should be considered superior to pure aluminum or the 1.5 per cent manganese alloy sheet. It comes within the limits outlined at the start of this article for material which we consider satisfactory for navy work, if properly heat treated and of sufficient uniformity.

Horace C. Knerr supplies some very interesting data showing the effect of the rate of cooling in heat treatment on resistance to corrosion:

Quenching Medium.	Degree of Corrosion.
A. Water at 60 degrees F.	Very slight
B. Water boiling	Slight, but more than A.
C. Quenching oil at 70 degrees F.	Same as B.
D. Air fan blast 65 degrees F.	Severe, scaled.
E. Still air 65 degrees F.	Very severe, deeply scaled.

While on the subject of Duralumin sheets, it might be opportune to refer what would at the present time seem to be the most approved method of riveting Duralumin sheets. This method has been recommended by the British Engineering Standards Association for Aircraft Purposes as follows: Rivets should as a rule be supplied in the annealed state and be finally heat treated and used immediately after quenching (before aging).

In some cases where the work on them is not severe it is possible to use them in the finally heat treated condition. Should however any of the rivets show signs of cracking in the head, it is desirable finally to heat treat the remainder of the batch, before the riveting work is done which work should be carried out immediately as hardening sets in rapidly.

Rock Island Arsenal Practice agrees in the main with the above. However they point out that annealed rivets are

strengthened noticeably by the cold work in driving. Shearing tests conducted in the arsenal on annealed rivets and on heat treated rivets driven in steel plates, immediately following the quench, and aged show a ratio of 1.6 in shear strengths of the two rivets, so that according to their figures six annealed rivets should accomplish the same purpose as four heat treated ones. Rivets should tap fit the holes; holes should be drilled and reamed to size, *i.e.*, a hole for ¼ inch rivet should be drilled 1/64 inch small and reamed at assembly to ¼ inch. It is not good practice to cold punch holes as the localized stresses around the hole are apt to embrittle the material and furthermore to start corrosion at this point.

In order to provide a sheet material which combine the attractive mechanical strength properties of Duralumin with somewhat greater ductility for punching, stamping, drawing, etc., some varieties of the ordinary Duralumin compositions are marketed in which the copper contents are reduced.

The Aluminum Company of America have standardized on two grades, known as A17S and B17S, whose mechanical properties fall within the limits set forth in the following tabulation:

	A 17 S		B 17 S	
Ultimate tensile strength	Anneal.	Tempered.	Anneal.	Tempered.
	18,000 to 23,000	36,000 to 42,000	21,000 to 24,000	45,000 to 51,000
Yield point	3,000 to 4,000	15,000 to 17,000	5,000 to 7,000	21,000 to 24,000
Elongation	22-28	20-23	21-26	20-23
Hardness, Brinnell	34-40	66-75	35-44	76-88

These special grades are tempered in the same way as the standard grades.

The Baush Machine Tool Company of Springfield also marked a variation of standard Duralumin, called grade A which has a lower copper content than the standard with be.ter

drawing qualities and about the same corrosion resistance, but with about 5,000 pounds less tensile strength and somewhat lower hardness in the tempered form. The manufacturer claims that with this material in the soft annealed temper, and with dies properly adjusted, practically any drawn, stamped or formed parts can be produced which can be made in steel or brass.

For an indication of the drawing qualities of the various aluminum sheets we ran some cupping tests on 3/16 inch thick stock where a ½ inch radius punch was forced through the sheet at constant speed with gradually but at constant rate increasing pressure until failure occurred by cracking.

The depth of the cup so obtained is a fair measure of the ductility of the sheet.

		Depth of Cup at Failure.
Commercially pure aluminum	Soft	.72 inch
	Temper No. 4	.65 inch
	Hard	.63 inch
1.5 Manganese sheet	Soft	.66 inch
	Temper No. 4	.46 inch
	Hard	.16 inch
Duralumin	Annealed	.35 inch
Modified A17S	Annealed	.61 inch
Modified B17S	Annealed	.55 inch
Brass	Soft	.88 inch

The figure for Duralumin is probably a little lower than might be obtained from freshly annealed stock, as our test samples were taken from sheet which had been stored for several months. At its best, though it would show less depth than the B17S.

Heat has an important influence on the strength of Duralumin.

The tensile strength of the tempered material decreases 10 per cent for an increase in temperature from room to 100

degrees C. and about 20 per cent at 150 degrees C., 35 per cent at 200 degrees C., 80 per cent at 300 degrees C. The elongation increases very little up to 100 degrees C.; at 150 degrees C. it increases about 10–20 per cent. There is no rapid increase in elongation up to about 250 degrees C. Hardness is decreased with increased temperatures. Strength and elongation increase somewhat with temperature below room temperature.

In case of momentary temperature rises, the original characteristics of the material will be restored as soon as the temperature goes back to normal providing the temperature has not exceeded about 350 degrees C. and the metal has not been stressed during the high temperature period.

Hot rolling of shapes such as angles, I beams, channels, etc., in high strength alloys has to date not been carried very far in this country. The demand for unalloyed metal very likely prevented or retarded the installation of new mills, etc., for the production of alloy shapes, the manufacture of which cannot be made commercially successful, until sufficient data are on hand to justify the expenditure of considerable money for this purpose. Experiments have been made however, during the last few years and a mill with rolls 21 inch diameter driven by a 400 horsepower variable speed motor has been built about three years ago by the A. Garrison Foundry Company but data of results are not available.

The time seems to have arrived for commercializing hot rolling on a broad scale and the requisite machinery will undoubtedly be promptly forthcoming for successfully producing high strength alloys in various forms and shapes.

Long channels and other sections of limited area can now be produced in Duralumin by heat treating a coil of flat strip then straightening and cold rolling it to shape immediately (within the first hour after quenching). The long straight members would be difficult to handle in heating and quenching if annealed material were used and heat treated after forming.

FORGING.

Various aluminum alloys lend themselves to forging with a great variety of physical properties.

An alloy with 97 per cent aluminum and 3 per cent copper gives 25,000 pounds ultimate tensile, 19,000 pounds yield point and 27 per cent elongation.

Paul McKinney reported results from Manganese-Copper-Aluminum alloys as follows:

Manganese 1 per cent, Copper 2 per cent, Aluminum 96.5 per cent.

	Tensile Strength	Yield Point	Elongation
Cold finished	27,750	27,750	12 per cent
Hot finished	21,000	12,000	26 per cent
Intermediate	25,000	23,000	17 per cent

Manganese 2 per cent, Copper 3 per cent, Aluminum 94.5 per cent.

	Tensile Strength	Yield Point	Elongation
Cold finished	32,000	31,000	8 per cent
Hot finished	27,500	15,000	22 per cent
Intermediate	28,000	22,000	21 per cent

However, the interest of the naval engineer lies more in the field of high strength forging alloys.

The most commonly used high strength forging alloy is Duralumin.

The forging of Duralumin is analogous to that of steel, except for the temperature range, and approximately the same power is required. However the design of Duralumin forgings varies considerably from steel or brass on account of the different characteristics of the metal. Aluminum requires greater draft and greater radii.

The workability of Duralumin is not quite as good as that of steel but it is better than that of forging brass. The billets used for forging are either rolled or hand forged, depending upon the results to be obtained, the hand forged ones being more uniform but of course more expensive. The piece to be forged should be heated in a non oxidizing furnace, preferably electric, at a temperature between 400 degrees C. and 450 degrees C. for 2 or 3 hours and then forged.

It should if possible be forged near the higher temperature but it should be noted that metal if forged above 455 degrees C. will be spoiled through hot shortness. Forging at lower temperatures does not affect the mechanical properties, rather improves them somewhat, but requires more strokes than at higher temperatures. If the metal should accidentally have been heated above 450 degrees C. no damage will result if before forging, the metal is allowed to cool to a safe forging temperature. After forging, the piece should be heat treated and aged in precisely the same manner as explained in the previous chapter on sheets.

The physical properties of Duralumin forgings are as follows (in the standard ½ inch test rod):

Ultimate tensile	Untempered 40,000 pounds.
	Tempered ($^1/_4$ inch-$^3/_4$ inch thick) 50,000-55,000 pounds.
	Above $^3/_4$ inch thick; somewhat less.
Proportional limit	20,000.
Elongation in 2 inches	tempered 18–22 per cent.
	untempered 10 per cent.
Hardness	85–100 Brinnell.

Pieces weighing 160 pounds and lengths of 10 feet have been turned out in commercial work.

Another forging alloy of somewhat lower physical properties but lower cost is used by the Aluminum Company of America under the trade name of 51S.

Its nominal composition is 0.25 to 1.5 per cent magnesium. 0.25 to 1.5 per cent silicon, remainder aluminum and its physical properties as follows:

Ultimate tensile	40,000 pounds average
Proportional limit	18,000 pounds
Elongation in 2 inches	16 per cent average
Brinnell hardness	90
Specific gravity	2.71

This alloy is heat treated and aged similarly to Duralumin.

Still another alloy has been developed by T. S. Fuller with the nominal composition of 6 per cent zinc, 2 per cent iron, 1.25 per cent magnesium, remainder aluminum and with the following characteristics:

Ultimate tensile	50–55,000
Proportional limit	25–30,000
Elongation in 2 inches	5 per cent
Brinnell hardness	100

It is heat treated at 500 degrees C., quenched in boiling water and aged in boiling water for about three hours. Its resistance to saltwater corrosion is excellent.

(To be Continued)

WORM GEARS AND WINDLASSES.

By COMMANDER H. S. HOWARD (C. C.), U. S. N., MEMBER.

About three years ago there developed failures of heavy duty worm gears used in machinery under the Bu. au of Construction and Repair which led to a rather comprehensive study of worm gears in general. This study brought out very strongly the facts that information as to worm gears was not easy to unearth and, generally speaking, few set rules existed as to certain important features of design of such gears, and the proper materials to use, except as each manufacturer had apparently, from the sum of his experience, evolved empirical answers.

The investigation carried out in this particular case led to a few definite conclusions and decisions as to future heavy duty worm gears which may be built and these conclusions will, it is hoped, serve to furnish the answer to troubles other engineers may experience and facilitate design in the future.

The worm gears which failed were all in big ship windlasses. The particular worm gear which furnished the occasion for this study was on the *Tennessee,* then completing in the spring and summer of 1920 at the Navy Yard, New York. The *Tennessee* is equipped with a type of windlass which may be said to be standard for modern United States battleships. It consists of three vertical wildcats on the forecastle deck mounted on shafts which pass directly down to the 3d deck where they end in the upper members of clutches or locking rings. To the other members of these clutches are secured large worm wheels. A shaft runs athwartship at this point. On it are formed three worms which gear with the worm wheels, and the necessary thrust members. To each end of this worm shaft is connected an electric motor, furnishing

power to operate the wildcats. Proper clutching arrangements are provided so that either one or the other motor, or both, can drive the cross worm shaft. As regards materials, the worm shaft and worms are of steel, while the worm wheels are built up of cast steel spiders with manganese bronze rims.

As the *Tennessee* approached completion, the usual preliminary tests of the anchor gear and windlass were carried out, these consisting in general of dropping anchors in turn in the shoal waters of the Navy Yard and heaving in, this procedure being repeated as often as necessary to ensure as far as possible that the windlass would be equal to its work under service conditions.

In these tests apparently minor troubles began to develop at once, these consisting principally in improper rendering of the chain over the wildcats and in a certain amount of heating of the worm wheels. There seemed nothing unusual in this as with the varying nature of the loads on any anchor windlass, and the actual very large loads in this case, it was not expected that everything would work without a certain amount of changing and working in. Changes were made in the wildcats and the large boltsters, which latter serve to guide the chain to the wildcats and from the wildcats to the chain pipes, and with these changes the chains ran smoothly in and out.

With these alterations, it was expected that the excessive loads would have been eliminated, and consequently the heating of the worm wheels would no longer occur. However, instead of conditions improving, the heating began to be accompanied by severe wiping or chipping off of the material of the worm wheel teeth. It was suggested that the windlass might have been somewhat abused during the early running, thus throwing it out of line. Another explanation, and a most natural one, was that the windlass was not receiving proper lubrication, either due to the use of improper lubricants or to unsatisfactory design of the oiling system. To meet these comments the whole assembly was carefully lined up, worm wheels and worms thoroughly cleaned and ground in, changes made in

the oiling system and the greatest care taken to use only the best lubricants, and anything else done and repeated which could be suggested to improve the conditions.

The ship left the Navy Yard with the windlass workable but still unsatisfactory, but away from the yard the troubles of heating and wiping of the worm wheels continued, if anything became aggravated, contrary to the usual expectations.

Eventually the vessel came to her official trials and on these trials there were to be carried out formal tests of the anchor gear, these tests comprising hoisting in of each anchor with a good scope of chain out, and finally hoisting in two anchors at the same time with over 50 fathoms of chain out on each. Trouble developed at once when these tests were started, this trouble as before evidencing itself in the heating of the worms and worm wheels accompanied by more or less severe cutting and wiping of the metal of the worm wheels. It was found possible to complete the single anchor tests, but as soon as the two anchor test was started, it was seen that it must be stopped if actual breakdown of the windlass was to be avoided. The heating of the worms and worm wheels became excessive while the wiping and paring off of the bronze worm wheel rims grew worse. The formation of a cutting, or more truly a very thin shaving from each worm wheel tooth, seemed always to occur in the same way. Toward the root of a tooth would appear a bright spot; on the next revolution this bright spot would increase in size toward the circumference of the wheel; soon it would be plain that a shaving was forming and in a few more revolutions this shaving would be scraped right off the tooth. The formation of these chips between the working surfaces of the teeth of the worms and worm wheels naturally aggravated the already bad conditions.

During the test, lubricants were poured on the gears but to no avail. Eventually the test was stopped as it was not wished to lay the ship up by an actual breakdown of the windlass.

Various features of the anchor gear as a whole as well as the windlass itself were blamed for the failure. The lead of

chain, particularly through the hawse pipes, was stated to be bad, so bad as to create an unusual and unexpected load on the windlass. However, the hawse pipes had been cast from the same patterns as those of the *New Mexico,* the latter ship having been in service with apparently a satisfactory windlass for a number of years. The material was stated to be too soft; but it was manganese bronze in accordance with Navy Department specifications, a material deemed excellent for work such as this for many years. On top of this it was known that the windlass on the *Tennessee* was practically identical with those on a number of the recent battleships with which there had been almost no trouble, in fact none except the normal amount which might be expected with a heavy duty piece of machinery subjected to intermittent, heavy and varying loads.

About this time the *Nevada* and *Florida* developed almost identical troubles with their windlasses. That on the *Nevada* is of the same general type as that on the *Tennessee,* only with two wildcats instead of three. The *Florida* has also a two vertical wildcat type of windlass but on the 3d deck the two worm wheels are operated by a single worm with steam engine drive.

In both these cases the breaking down action was the same as in the windlass of the *Tennessee,* namely great heating of the worms and worm wheels, accompanied by cutting and wiping of the worm wheel teeth. Both ships had suffered from such troubles since their original commissioning. On the *Nevada,* worm wheel rims had already been replaced once before and on the *Florida* twice, but these had been more or less isolated instances and were treated generally in the light of ordinary repairs. However, the windlasses on both ships now developed serious conditions just at the time when the troubles of the *Tennessee* were fresh in mind and as yet without a remedy. Consequently they played their part in making even more necessary the finding of some answer to the vexing problem. The *California,* too, a sister ship of the *Tennessee*

with an identical windlass was nearing completion and it was felt certain that similar troubles would develop with her windlass. This opinion, it may be noted was fully substantiated and added its weight to the necessity for a solution of the existing problem.

The easy answer to any such problem is, of course, to take out the machine which cannot do the work set it, and install a new machine big enough to do the job. However, that is hardly a scientific engineering solution and in this case such a solution would have cost hundreds of thousands of dollars.

To find the answer, the whole design together with the materials used was analyzed carefully. First of all were considered conditions outside the windlass. They consisted in shape of hawse pipes and lead of chain. As previously remarked the *Tennessee* hawse pipes were cast from the same patterns as those for the *New Mexico,* and it further developed that the patterns in this case were those manufactured and used for the *Mississippi.* Since trouble had never been experienced on these other ships, it was apparent that the hawse pipes and lead of chain on the *Tennessee* might be thrown out as the possible cause of the trouble.

Within the limits of the windlass gear itself, study of worm gears in general, and of the performance of this gear in particular, indicated that the causes should probably be found in one or more of the following features of design: unit tooth pressure, materials and helix angle of the gears. It was felt that poor workmanship, misalignment of parts and kindred causes could be completely eliminated from consideration since every endeavor had been made to give proper workmanship, and no matter how frequently the gears were trued up and ground in, or the whole shafting raised and realigned, the typical troubles reproduced themselves each time.

As regards tooth pressure, this it may be noted is an empirical quantity. Theoretically, in a straight worm, such as this, line contact only takes place between the teeth of the worm and gear. Actually, due to the pressure, surface contact must

occur to some degree. Also, contact takes place at times not only along one tooth of each gear, but along two and three teeth. However, in order to give some measure of the tooth pressure, it is practice in the designing of worm gears to assume that the total load on the gear is taken by the full surface on one side of one tooth of the worm wheel. Although empirical, this method, taken in connection with knowledge as to performance of existing gears, does give a method by which it is possible to calculate the necessary area of tooth surface, thickness at the root and other dimensions. Generally speaking, on heavy duty worms a maximum tooth pressure of 1,000 pounds per square inch is the limit of good practice, but in the case of the *Tennessee* a maximum pressure of 1,400 pounds had been allowed in the design. This at once seemed to point to excessive tooth pressure as one at least of the principal causes of trouble. However on the other side of this question, anchor gear is very intermittently used, and it is further but very rarely that the maximum designed load is encountered. Under load conditions such as these, it is considered good engineering practice to admit of unit loads and stresses in the neighborhood of 50 to 100 per cent in excess of a regular working load. An allowed unit maximum tooth pressure of 1,400 pounds, with good practice allowing 1,000 pounds for regular working load does not therefore seem unreasonable. Moreover, it is known that other windlasses with the same allowed maximum tooth pressure have operated successfully for years.

While studying this question of tooth pressure, consideration was given to the possibility of substituting Hindley worms for the straight worms actually installed, with the idea that in this way greater tooth surface would be brought into play, and the unit pressures and loads thereby reduced. In a Hindley worm, contrary, it is believed, to the popular idea, line contact only, just as in a straight worm, is theoretically obtained. However, this line contact is much greater in a Hindley worm than in a straight worm, and moreover, practi-

cal conditions do not wholly follow theory, for an essential feature of a Hindley worm installation is the grinding in of the gears with an abrasive. The net result is that the surface in contact between the teeth of worm and gear is much greater in a Hindley than in a straight worm. Photographs of sections of Hindley (and Lanchester) worms show practically complete contact over two teeth in the area of contact.*

Worm gears of this type have, however, the decided disadvantage that the worm must be most accurately placed in relation to the worm wheel, and provision must not only be made for adjustment toward or away from the center of the worm wheel, but for adjustment of the worm in the direction of its axis. It was felt that such an arrangement would be most unsatisfactory with gear of this type.

Taking everything into consideration, excessive tooth pressures were eliminated as a possible cause of the troubles in the gear, and solutions along the line of reducing pressures were dropped at least for the time as possible remedies.

The next point taken up was that of the material of the worm wheels. The easiest criticism of the gear, when watching it in operation was that the material of the worm wheel rims was too soft, for the steel worm apparently pared off shavings of bronze with the greatest ease. Nevertheless, the rims were Navy specifications, manganese bronze, a bronze of the best quality and of high tensile strength. This bronze was in use, moreover, in worm wheels of practically all large windlasses in service. It was felt, though, that some difference might exist in the foundry practice where the different rims had been cast, this opinion being somewhat borne out by the fact that in the case of the windlass troubles on both the *Nevada* and *Florida,* those worm wheel rims had, it was known, been Navy standard bronze. That such a difference did exist proved to be the case, for it developed that in the

*NOTE. The best articles located upon the subject of worms of Hindley type are "The Hindley Worm and Gear" by John Edgar in "Machinery" of December 1908, and "Worm Gear and Worm Gear Mounting" by F. W. Lanchester in the "Automobile Engineer" of January 1917.

rims for the windlasses of a number of battleships a so-called "modified manganese" had been used, and in no one of these windlasses had actual trouble been experienced in service. This "modified manganese" had, it developed, elements introduced which greatly increased the hardness and strength as compared with the standard manganese bronze. With this information it was felt that at last an upward step had been taken towards the goal.

It was realized also that the Bureau of Ordnance in its work makes use of large size composition screw and worm gears, subject not only to great loads but heavy shock. When the subject was taken up with that Bureau it developed that up to a few years previously, manganese bronze had generally been used, but it was found that it did not stand up under a heavy unit frictional load as in a worm or screw gear. Tests had been carried out by that Bureau in an endeavor to find what compositions were best suited to the work and from these tests, and the experience in service, it was found that a well defined characteristic of standard manganese bronze was its wiping and shaving off when subjected to heavy loads in a gear of this type. The bronze in the *Tennessee* windlass performed in the identical way described by the Bureau of Ordnance. This confirmed the opinion that one cause of failure, if not the whole cause, had been found in the use of Navy specification manganese bronze.

It then became necessary to decide what material to use to give the most satisfactory results. Already one manufacturer of windlasses had stated that for their gears they used a "modified manganese" of much greater hardness and strength than the standard composition. This view was confirmed by another foundry, one of the best known in the country, which (although it had cast the rims for the *Tennessee* windlass) now in response to inquiry stated that the use of a very high strength, very hard bronze was what they would recommend for heavy duty worm gears, and they suggested a mixture higher in copper and aluminum than standard manganese but

otherwise very much the same; in other words a "modified manganese." The Bureau of Ordnance on the other hand had been led in its tests and investigations away from manganeses, plain or modified, and for elevating screws and other large parts had adopted so-called "Bearing Bronze" and for small parts such as worm gears of elevating and training gears of broadside guns, aluminum bronze. The former is a low tensile strength phosphor bronze while the latter is about 86 copper, 8 aluminum, and 4 iron with a trace of tin. In the course of this investigation it was learned (truly it is believed) that the worm gear drive of the Fordson tractor was unsatisfactory and the tractor consequently a failure until aluminum bronze was used for the driving worm wheel, when all troubles disappeared.

To the question of material, we now had two answers; the first to use a very hard, very strong bronze, the second to use a much less strong bronze, either phosphor or aluminum. Both agreed in but one thing, namely, that standard manganese bronze was not the thing to use, and actually from the experience of users it appeared that either the very hard, very strong bronze, or the low tensile bronze could be used with success. The only theory which it has been possible to evolve so far for this result is that in the case of the hard bronze, the bronze is so hard and strong that it resists the abrasive tendencies of the steel worm, while in the case of the softer bronze, the material will flow as the pressure between worm and worm wheel increases, thus increasing the bearing surface and decreasing the unit pressure until the load can be carried.

The completion of the study of materials brought up the last subject for investigation, that being the proportions of the gear itself and particularly the helix angle, or angle of advance. The worm in the *Tennessee* gear had a length of 17½ inches, a 4 inch pitch and a pitch diameter of 10.036 inches. This gave for the helix angle the following value:

$$\delta = \tan^{-1} \frac{\text{pitch}}{\text{pitch circumference}}$$

$$= \tan^{-1} \frac{4}{\pi \times 10.036} = \tan^{-1} .127$$

helix angle = 7 degrees 20 minutes.

The gear had 4 inch pitch, 85.312 pitch diameter with 67 teeth. All these dimensions seemed to follow previous good practice in windlasses where self locking worms are particularly important.

However, attention was called to an article in Halsey's Hand Book on the subject of worm gears and particularly their efficiency in its relation to helix angle. In this article the following statement occurs:

"The durability of worm gearing is largely dependent on the angle of the helix with the tangent to the pitch line. In order that a worm gear may be durable, the helix angle should be large—that is, the worm should be a steep pitch screw. This fact is established by theory, by experiment and by experience. The unfortunate experience that many have had with worm gearing is due to bad design and not to any inherent defect of the construction."

Further, after discussing a long series of tests of worm gears, and mathematical investigations it is stated:

"Summing up the results of the investigation it was found that all worms having helix angles greater than 12 degrees 30 minutes were successful, that all having angles less than 9 degrees were failures from rapid wear, while between these angles some were successful and some failures."

The answer was now before us. With a helix angle of 7 degrees 20 minutes in this heavy duty worm gear the way for failure was made easy, and when with this helix angle there was combined a gear of standard manganese bronze, failure was practically sure to occur. Experience had shown that some gears with this same helix angle did work, but this was

generally when combined with a very hard bronze. Moreover, reports show that even these gears were not far from failure. We could probably make a gear of the type in question operate if the gear wheels were made of proper materials, but if a sure solution was wanted, it meant not only new gear wheels of hard gear bronze, or aluminum bronze, but in addition a change in the design and layout to increase the helix angle to some value over 12 degrees 30 minutes.

For the *Tennessee* something had to be done quickly for very little time was to be available for overhaul and the fear was constantly in mind that the windlass might break down entirely and thus put the ship out of service as completely as though she had no engines. Consequently it was decided in her case simply to install new worm wheel rims of very hard bronze. This was done and the windlass has kept operating to date. Practically the same solution had to be adopted in the case of the *Florida* for the arrangement of her windlass was such that a redesign would have been difficult. Here, however, it was decided that a direct comparison of the two metals claimed as the superior of manganese bronze would be of interest, so the two worm wheel rims were replaced with rims of different compositions, one of a special very hard gear bronze (one of the "modified manganeses") and the other of aluminum bronze. As mentioned earlier in this paper, this windlass has a single worm in mesh with both worm wheels, so no better comparison of the performance of the two materials can be imagined. Reports from service will be looked for with interest.

In the cases of the *California* and *Nevada,* time was not so pressing and it was felt that here complete solutions of the past troubles should be made, using all the information gained in this investigation. Consequently in these windlasses, not only were new worm wheel rims of special hard bronze installed, but new worms, with double the helix angle of the old provided. This gave an angle in the neighborhood of 15 degrees, well within the range of successful worms. To re-

tain the same motors for driving the gears, two to one reduction gears were installed between the motors and worm shafts. Thus in these gears every feature which study had shown to be defective was as far as possible made satisfactory.

The new installations were carried out on both ships about the same time, during the late spring and early summer of 1922. Since that time both ships have operated practically continuously, the *California* as flagship of the Commander-in-Chief of the Battle Fleet and the *Nevada* during some months of the time going to Rio de Janeiro for the Centennial Exposition. It is very reasonable to assume that if the flagship of the Battle Fleet had been slow in getting up anchor or has had trouble of the kind, we should have heard of it, while the trip of the *Nevada* to South American waters caused her to anchor in open roadsteads and heavy mud bottoms where at times the strain on the gear was sufficient to part an anchor chain.

Within the past few weeks reports from both ships as to the performance of their windlasses have been received and the wording of both is almost identical. The *Nevada* has stated "The mechanical operation of the gear has been completely satisfactory," and the *California* reports "that the anchor windlass installation * * * has been perfectly satisfactory." Just a year and a half ago the *Nevada* was reporting that "The condition of the anchor windlasses * * * is such that there is considerable doubt of the ability of this ship to maintain her position in the fleet under war conditions," while the officers of the *California* "did not consider it advisable to operate the gear more than absolutely necessary due to the probability of damaging it to such an extent as to make it entirely inoperative."

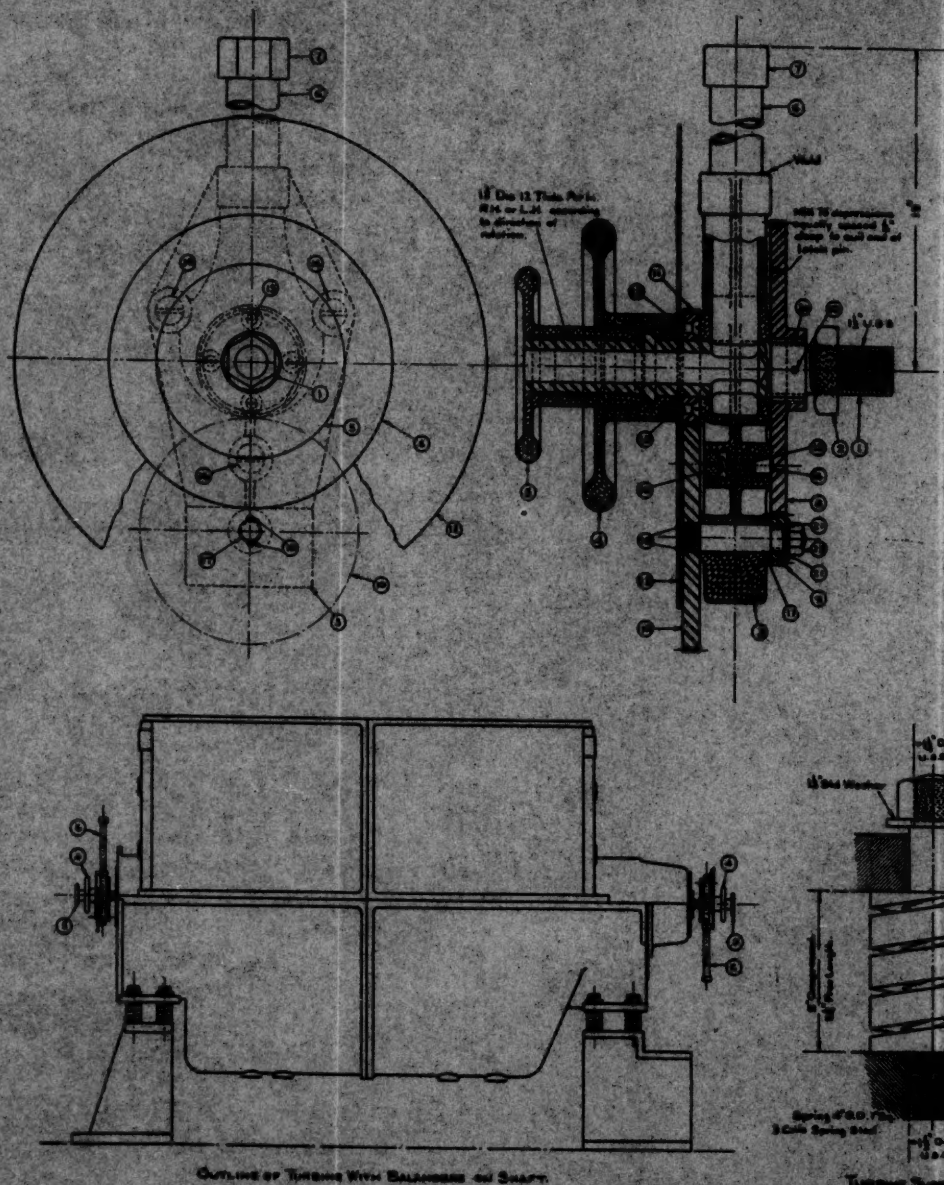
These reports by their tone indicate more clearly than could anything else, a change in operation of this machinery from almost absolute failure to entire success. To those who carried through this analysis and investigation, which at times seemed so hopeless, no better reward could be given.

METHOD OF BALANCING TURBINE ROTORS OF SCOUT CRUISER *RALEIGH*.

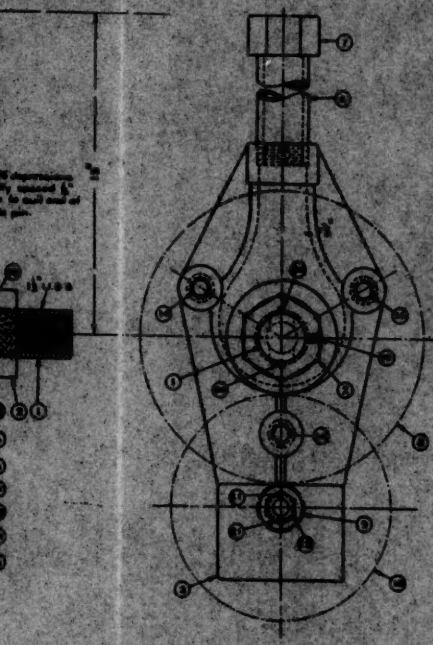
By COMMANDER CARLOS BEAN, U. S. N., MEMBER.

Previous to balancing a turbine rotor dynamically, it is most essential to obtain as perfect a static balance as possible. A rotor which is out of balance statically is surely out of balance dynamically, and, except in case of a couple, dynamic unbalance is merely the result of residual static unbalance. Perfect working conditions are necessary in balancing a rotor statically, especially as regards freedom from air currents from blowers, or from the opening and closing of doors or windows, and from local vibration of the shop floor. The knife edges on which the shaft is mounted should not be over ¼ inch in width. A wider knife edge offers too much resistance to turning, especially if any dust particles settle on the shaft or the edges. Case hardened collars should be made and fitted over the shaft journals to take the weight of the rotor on the knife edges, for a ¼ inch knife edge would score the shaft.

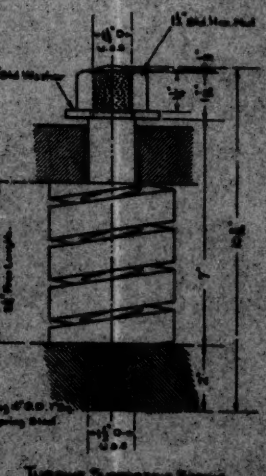
Then instead of using putty as a trial weight, known weights are placed on a graduated adjustable arm which extends from a collar secured to the shaft. After these weights have been applied to the rotor so that the rotor will stop at any point, a further refinement is made by testing for the least weight which will start the rotor turning at a radius of about 12 inches. Some one point may be found where this trial weight about 8 ounces will not overcome friction and inertia and will not start the rotor turning, thus showing a slight heavier side. The weight on the rotor may then be further changed and a nearly perfect static balance can be obtained. Two of the I. P.



Outline of Turbine With Bearings and Shaft



Number	Name.
1	Central Spindle.
2	Spindle Locking.
3	Cutter.
4	Adjusting Handwheel.
5	Locking Handwheel.
6	[illegible] Lock Plate
7	Pipe Cap.
8	[illegible]
9	[illegible]
10	[illegible]
11	[illegible]
12	Guard [illegible]
13	Machine Screws [illegible]
14	Latch Pin [illegible]
15	Latch Pin Spring [illegible]
16	Latch Spring Pins [illegible]
17	Chain Rebate [illegible]
18	Machine Screws [illegible]
19	Set Screw [illegible]
20	Key [illegible]
21	Key [illegible]
22	Hexhead [illegible]



Turbine Supporting Stands.

DYNAMIC BALANCING DEVICE FOR TURBINE ROTORS.

Scale [illegible] May [illegible]

rotors of the *Raleigh,* having been balanced statically as described above, showed perfect dynamic balance. The other I. P. rotors and the four (4) H. P. rotors, similarly balanced, required less than the additional weight of six (6) ounces to place them in dynamic balance.

BALANCING DEVICE.

The balancing device shown on Plate I weighs about sixty (60) pounds and was made in the machine shop of the Bethlehem Shipbuilding Corporation, Fore River Plant; at an approximate cost of $100. It is designed to locate the position of the unbalanced part of the rotor and to give an approximation of the weight necessary to be applied to the rotor to place it in dynamic balance.

The balancing device consists of a spindle (1), about 12 inches long which is screwed into the end of the rotor shaft, care being taken to locate this hole accurately upon the axis of the shaft. Upon this spindle is mounted a hollow center casting (3), into one side of which is screwed a section of 1¼ inch extra strong L. W. steel pipe (6), the outer end of which is closed by a pipe cap (7). This center casting with attached pipe is free to revolve about the spindle, and can be set in any position by means of a handwheel (4), and train of four gears, (8), (9), (10) and (11), gear (11) being keyed to the central spindle. By means of a second handwheel (5), the spindle and center casting can be securely locked together in any desired position.

To add weight to overcome dynamic unbalance, shot are poured into the axial hole in the spindle, from which point they roll into the hollow section of the center casting and then are thrown into pipe (6) by centrifugal motion.

The rotor to be balanced is assembled within its casing and the complete turbine is mounted upon the testing foundation. Heavy coil springs, through which the holding down bolts pass, are placed under the turbine feet. The holes in the

turbine feet for the holding down bolts are 1¾ inches in diameter while the bolts are 1½ inches in diameter. A clearance of about ⅛ inch is also allowed between the holding down bolts nuts and the top of the foot. With this method of mounting, the entire turbine is free to move in all directions upon its foundation.

METHOD OF MAKING TEST.

Steam is turned on the turbine, and the speed of the rotor is gradually increased up to about 600 R. P. M.—the maximum speed with which this device is designed to operate. The approximate amount of vibration is shown by dial micrometer indicators placed in contact with the bearing caps and the flanges of the casing. Note is made of the vibration shown at each end of the casing. Steam is then turned off the turbine, and a balancing device is secured to each end of the rotor shaft.

Steam is again turned on and, with the rotor revolving, the amount and the angular position of the balancing weights required are found by trial and error. A spoonful of shot is first poured into the 1¼ inch pipe through the axial hole in the center spindle at that end of the turbine which shows most vibration. The effect of varying weights with different positions of pipe (6) is noted. A position of the pipe (6) with a certain weight of shot is finally found where the vibration is reduced to a minimum. The balancing device is then locked in position by handwheel (5). The vibration at the other end of the shaft is now reduced to a minimum in the same manner. A slight change in the position of the first balancing arm and the weight therein may now be necessary as the result of adding weight to the opposite end.

The turbine is then stopped and the angular position of the balancing arms is marked on the ends of the rotor shaft. The shot, no longer being held out by centrifugal motion in the end of the pipe (6), are drawn off through axial hole in the center spindle, and are weighed.

The permanent weights and their position to accomplish dynamic balance having thus been determined, are transferred to the rotor wheels, and the turbine is then given a running test at varying speeds up to 25 per cent overspeed—vibration at all speeds being noted and compared by means of the dial micrometer indicators.

THE PRACTICAL SOLUTION OF SOME SHIPBOARD PROBLEMS.

By LIEUTENANT C. C. MCMILLAN, U. S. C. G., MEMBER.

AN AUTOMATIC CUT-OUT SWITCH FOR REFRIGERATING MACHINES.

With refrigerating machines of the dumb bell type, it is essential that a constant supply of cooling water be maintained about the drum containing the compressor while the machine is in operation.

Should the supply of cooling water be stopped for several minutes the temperature in the compressor will rise excessively. If this condition continues the compressor pressure will increase until the counter weight revolves with the machine thus acting as a safety device protecting the machine against damage by excessive pressure, but it does not protect the machine against damage by jerking, and pounding caused by the revolving counterweight.

An automatic stopping device consisting of a simple contact breaker operated by a diaphragm which was connected to the condensing water supply by a one-eighth inch pipe was originally installed with the refrigerating machine on the Coast Guard Cutter *Mojave,* but proved to be unsatisfactory owing to the extreme sensitiveness of the diaphragm arrangement. A slight variation in pressure of the water supply would break the circuit and stop the machine. The impracticability of such a device is obvious. To overcome this difficulty the contrivance shown in Fig. 1 was conceived and made aboard the Coast Guard Cutter *Mojave* from such material as could be found in the scrap pile.

The device consists of two cylindrical chambers secured together and provided with a port at the lower end to allow water

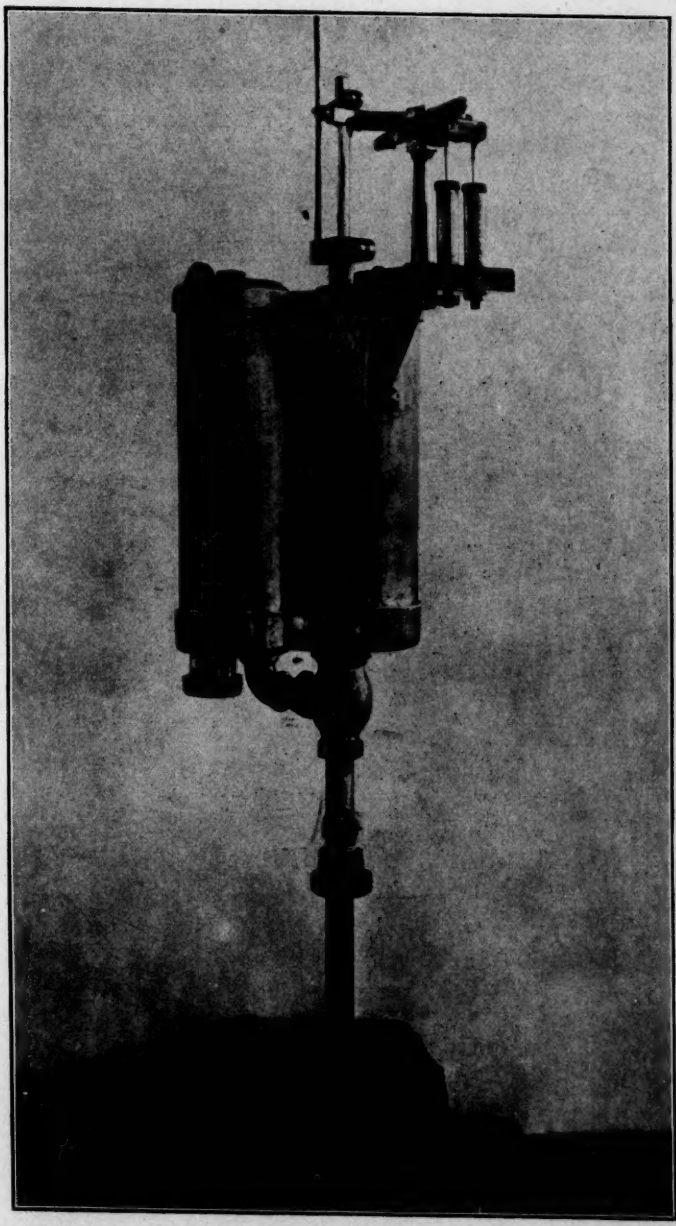


FIG. 1.

to pass freely from one chamber to another. The smaller contains a perforated tube which is connected outside the chamber to a one-eighth inch pipe leading to the cooling water supply line. This tube is considerably larger than this one-eighth inch pipe and is an expansion space thus eliminating the violent agitation that otherwise would result should the water be injected directly to the chamber at service pressure. There is also another tube to which the water flowing into this chamber is freely discharged, but it is of sufficient length to maintain a predetermined water level. Near the lower end of this tube is a small orifice through which the water in the chamber escapes slowly after it has fallen below the upper end of the tube.

The larger chamber contains a float. To this float is attached a long stem which passes through a guide in the top cover of the chamber.

The switch consists of a simple arrangement of three levers and one spring constructed so as to snap in and out of contact. A positive contact is assured by means of two small rods (insulated from the mechanism) which dip into the mercury contained in two iron cylindrical cups. This method also does away with troubles due to friction, burnt and corroded contacts, etc., as is often encountered in other switches.

The entire switch is mounted on an insulated base which is secured to the larger chamber and is operated by one of the levers connected to the long stem attached to the float.

AN OIL INDICATOR.

Owing to the necessity of frequent soundings of ship's fuel tanks to determine the amount on hand and expended in a given unit of time considerable time was expended in obtaining the necessary data prior to the installation of the device shown in Fig. 2. However, since its installation this loss of time has been overcome and better and quicker results have been obtained.

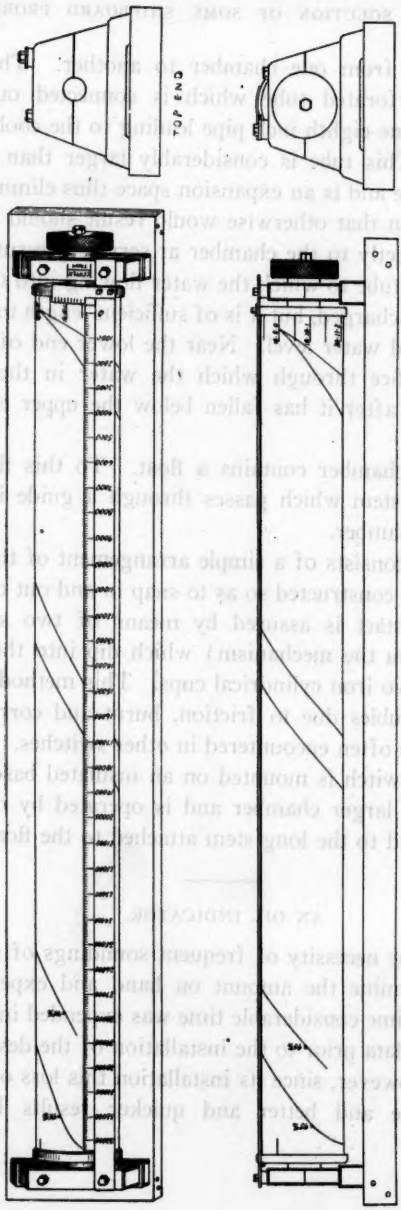


FIG. 2.

The description of this device (indicator) follows: It consists of a three inch cylinder mounted on suitable bearings with a knurled knob attached to one end of the shaft to facilitate revolving the cylinder freely. The scale is made of steel, and is so laid out as to represent the tons in gallons, as shown on the original drawing. The scale is properly secured to bearing tops in dead line with the parallel center of the cylinder. It is graduated in gallons from zero to the maximum capacity of the largest tank. At the end of the cylinder just above the knurled knob the tube is divided into feet representing the depth of the tanks from zero to the maximum depth of the deepest tank. The small vernier is secured to the bearing top for use as a stop mark, and enables the feet to be divided into tenths for close calculation.

The curves representing those on the original drawing were laid out and colored red and black in order to be able to discern the different tanks being checked. A small plate with the tank number and its color is screwed to the bearing frame to avoid mistakes.

When it becomes necessary to check the amount of oil in a tank the only information necessary is that derived from sounding, as the scale is in feet and inches and is set to correspond with the soundings, and the intersection of the curve line with the graduated scale gives the amount in the tank in gallons or vice versa.

This indicator may be constructed at very little expense, may be applied to any set of ship's tanks, and several tanks may be laid out on the cylinder.

In conclusion: This instrument has been in use on board the Coast Guard Cutter *Mojave* for some time, and in practical use has proven to be highly satisfactory and reliable.

FEED INDICATOR.

This is shown in Fig. 3; it consists of a standard steam tight lighting fixture with the glass piped as indicated by the legend on the sketch. When in operation this instrument

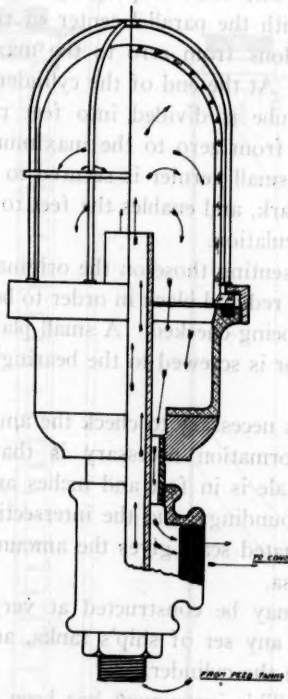


FIG. 3.

shows a stream of water, the flow of which is indicated by the arrows. This enables the officer of the watch to detect at a glance whether the feed is on or off, and the amount of water being used.

SALINITY INDICATOR.

The electrical salinity indicator as installed on the Coast Guard Cutter *Mojave* is shown in Fig. 4 and consists of the following:

(1) A zero to fifteen scale portable voltmeter
(2) Twelve dry cell units
(3) Two one-half inch spark plugs
(4) One one-half inch standard cross.

The voltmeter is mounted on the control platform in the engine room and instantly records any change in the condensate. With the water below one grain of chlorine per gallon the voltmeter registers zero. With sea water the voltmeter registers fourteen and one-tenth volts. The scale has been graduated into grains chlorine per gallon between zero and fourteen and one-tenth volts.

The twelve dry cells give an applied electro motive force of eighteen volts across the terminals of the spark plugs which are located on the filter tank in the fire room.

The spark plugs are of the ordinary commercial one-half inch standard type. The points on the screw points are removed. The plugs are screwed into the one-half inch pipe cross. A circulation of water is maintained across the points in the following manner: A one-half inch pipe connects the initial condensate compartment with the cross containing the spark plugs, and from the cross a similar pipe leads into the last compartment of the tank. On the end of this pipe a cap is fitted with a one-thirty-second inch hole drilled through the end.

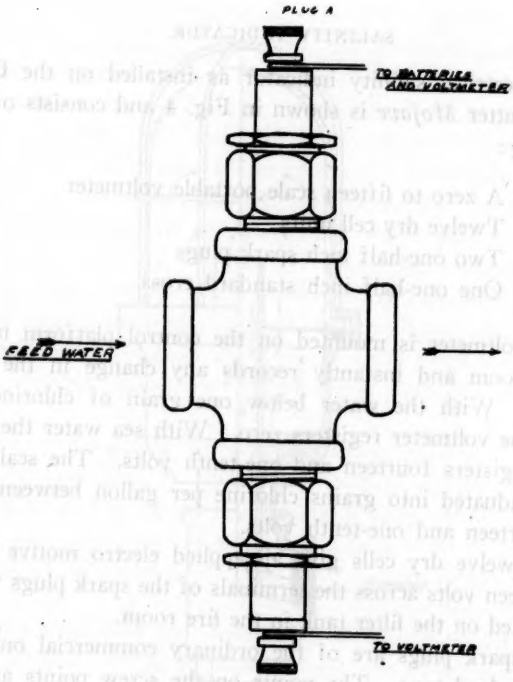

PLUG A
TO BATTERIES AND VOLTMETER
FEED WATER
TO VOLTMETER
PLUG B.

FIG. 4.

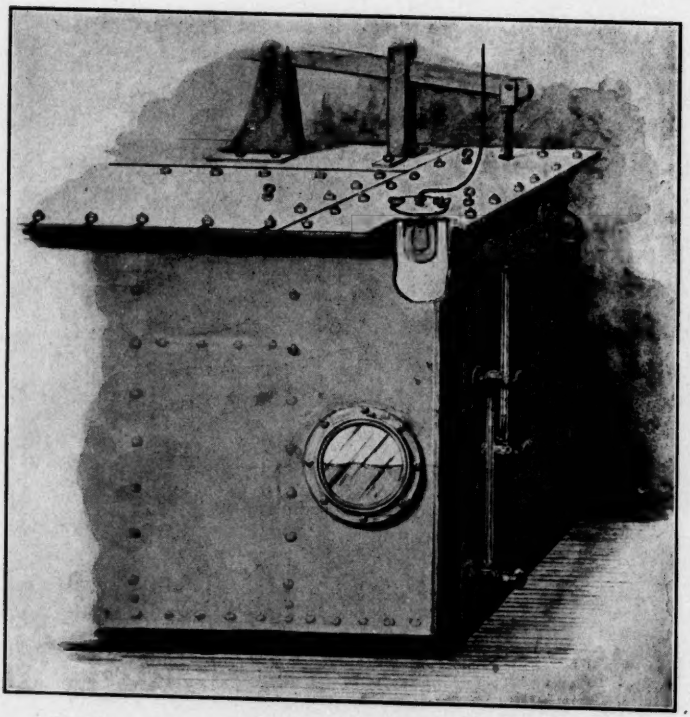


FIG. 5.

The principle on which this indicator functions is as follows: The resistance of water with a low chlorine content is very high with the consequent low reading on the voltmeter scale. As the chlorine content increases in the condensate, the resistance of water flowing between the two plugs decreases in direct proportion to the increase in salinity.

The wiring is as follows: The positive electrode of the battery is connected to plug "B" and the plug "A" is connected to the positive terminal of the voltmeter. The negative terminal of the voltmeter is connected to the negative terminal of the battery comprising a simple loop circuit.

OIL DETECTOR.

This is shown in Fig. 5 and is considered self-explanatory. It consists of an airport glass let into the frame of the feed tank and so arranged in place that the water level in the tank is in the middle of the glass and constantly in sight with a light inside of the tank. The surface of the water is plainly in sight and the presence of any oil in the water is detected at once.

TESTS OF DIAMOND SOOT BLOWERS.

By Lt. Comdr. H. H. Norton, U. S. N., Member.

On January 30th, February 1st and February 6th, 1923, official tests by authority of the Bureau of Engineering, Navy Department, Washington, D. C., were conducted at the Fuel Oil Testing Plant, League Island Navy Yard, Philadelphia, Pa., for the purpose of determining the efficacy of mechanical soot blowers in cleaning a marine water tube boiler fired with oil fuel, and to ascertain what would be the boiler and furnace efficiencies under the three following conditions:

(*a*) Where heating surfaces were fouled as under normal working conditions.

(*b*) Where heating surfaces were as clean as they could be made by blowing soot from the tubes through the side cleaning doors of the boiler in the usual manner with hand lances.

(*c*) Where the heating surfaces had been cleaned by the use of mechanical soot blowers.

The Babcock & Wilcox *Oklahoma* type experimental battleship boiler, installed at the Fuel Oil Testing Plant, was used in these tests. The heating surface, consisting of 792 2-inch tubes and 22 4-inch circulating tubes, totals 4,000 square feet. The furnace volume is 445 cubic feet. The diameter of the steam drum is 36 inches. The boiler is built for a working steam pressure of 295 pounds per square inch gauge. The boiler was fitted with four self-contained, draft-control burners, each built with a steam turbine driven fan, the speed of which controls the amount of air admitted to the furnace for combustion. The boiler was equipped with mechanical soot blowers of the Valv-in-Head type, manufactured by the Diamond Power Specialty Corp., of Detroit, Mich.

Six soot blower elements were inserted from each side of the boiler, each extending half way across the tube bank, the

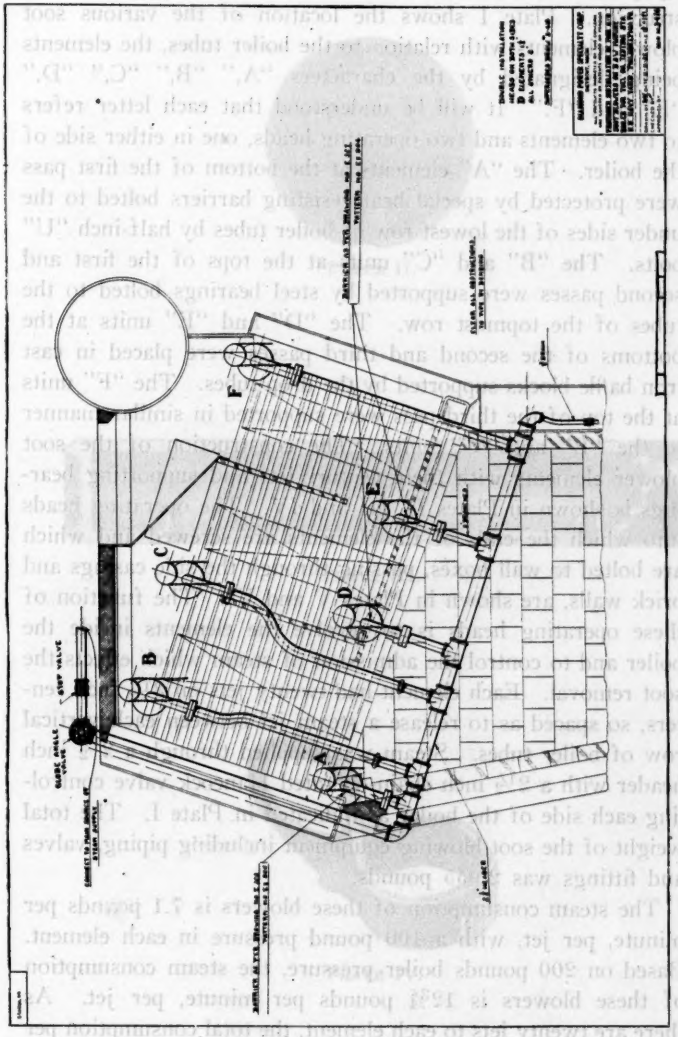


PLATE I.

equipment in both sides of the boiler being similar in construction. Plate I shows the location of the various soot blower elements with relation to the boiler tubes, the elements being designated by the characters "A," "B," "C," "D," "E" and "F." It will be understood that each letter refers to two elements and two operating heads, one in either side of the boiler. The "A" elements at the bottom of the first pass were protected by special heat resisting barriers bolted to the under sides of the lowest row of boiler tubes by half-inch "U" bolts. The "B" and "C" units at the tops of the first and second passes were supported by steel bearings bolted to the tubes of the topmost row. The "D" and "E" units at the bottoms of the second and third passes were placed in cast iron baffle blocks supported by the drop tubes. The "F" units at the top of the third pass were supported in similar manner to the "B" and "C" units. The construction of the soot blower elements with their venturi jets and supporting bearings is shown in Plates II, III and IV. The operating heads into which the ends of the elements are screwed and which are bolted to wall boxes, passing through the side casings and brick walls, are shown in Plates V and VI. The function of these operating heads is to revolve the elements inside the boiler and to control the admission of steam which effects the soot removal. Each element had twenty jets on 3½ inch centers, so spaced as to release a steam jet between each vertical row of boiler tubes. Steam was supplied through a 2½ inch header with a 2½ inch chain-operated Hancock valve controlling each side of the boiler as indicated in Plate I. The total weight of the soot blowing equipment including piping, valves and fittings was 2,955 pounds.

The steam consumption of these blowers is 7.1 pounds per minute, per jet, with a 100 pound pressure in each element. Based on 200 pounds boiler pressure, the steam consumption of these blowers is 12¾ pounds per minute, per jet. As there are twenty jets to each element, the total consumption per element is 255 pounds per minute of blowing. The average

PLATE II.

PLATE III.

PLATE IV.

PLATE V.

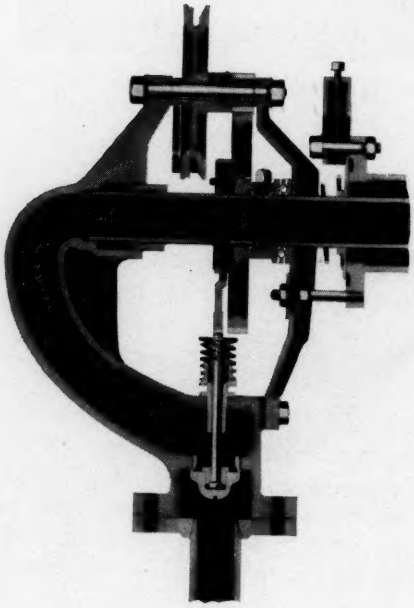


PLATE VI.

time that these elements are open for blowing is twenty seconds, so the steam consumption on this basis for the whole boiler is about 1,020 pounds.

For any variation in pressure over 200 pounds, steam consumption can be found on Plate VII, the initial boiler pressure being given on the vertical scale. The curve from this pressure is followed to where it intersects the diagonal line which indicates the number of jets in the element. The figures given in the horizontal scale directly below this point indicate steam flow in pounds per unit, per minute.

As these test runs were of short duration, the utmost endeavor was made to keep every factory constant so as to minimize the chances of error and so that the only variable would be the rate of heat transfer through the boiler tubes which would vary inversely with the soot accumulation on the tubes and which would be measureable inversely by the temperatures of the flue gases in the stack. The steam pressure on the drum and at the burners, the feed water temperature and the oil pressure and temperature at the burners were carefully controlled and recorded. The water level in the drum before, during and at the end of each test was kept as nearly steady at the same point as possible. The feed water and the fuel oil supplied were carefully weighed and the rate of supply of each was maintained constant. The amount of oil burned was primarily determined by the amount which would not cause a positive pressure to be built up in the furnace. Flue gas analyses were taken continuously during all these tests, the CO_2 ranging from 12 to 14.7 per cent, indicating excess air ranging between 27 and 10 per cent, the average CO_2 reading being approximately 14 per cent. See Plate VIII. The smoke density was measured by the Ringelman scale.

The stack temperatures were charted by a recording pyrometer and are shown in Plate IX for test 26-1, January 30, 1923; Plate X for test 26-2, February 1, 1923; and Plate XI for test 26-3, February 6, 1923.

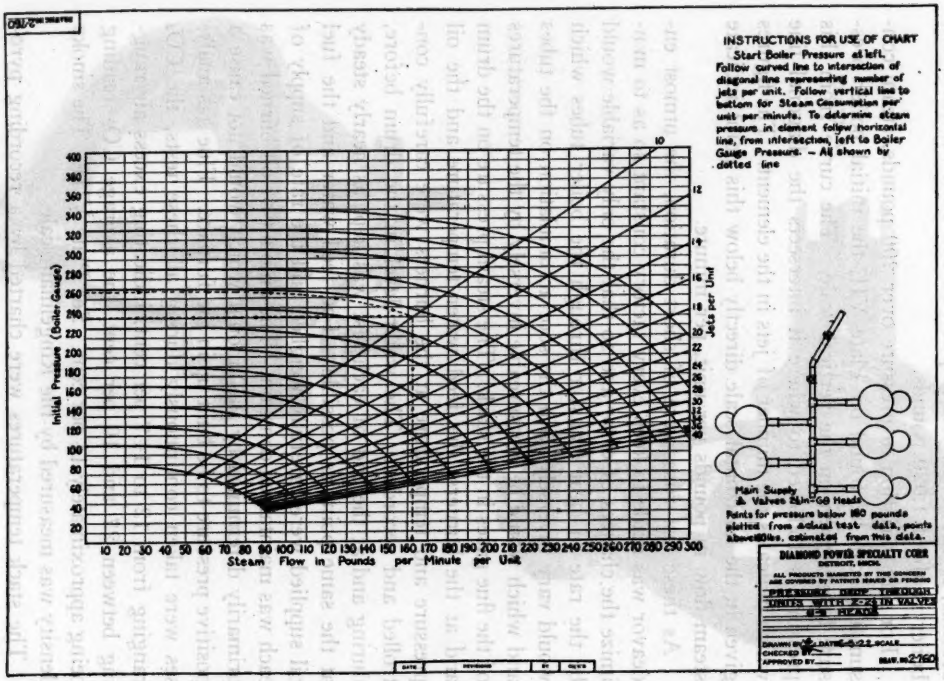

INSTRUCTIONS FOR USE OF CHART
Start Boiler Pressure at left. Follow curved line to intersection of diagonal line representing number of jets per unit. Follow vertical line to bottom for Steam Consumption per unit per minute. To determine steam pressure in element follow horizontal line, from intersection, left to Boiler Gauge Pressure. – All shown by dotted line
Initial Pressure (Boiler Gauge)
Steam Flow in Pounds per Minute per Unit
Jets per Unit
Main Supply & Valves 2½"
Heads
Points for pressure below 180 pounds plotted from actual test data, points above 180 lbs. estimated from this data.
DIAMOND POWER SPECIALTY CORP.
DETROIT, MICH.
UNITS WITH 2" IN VALVES
DRAWN BY
DATE 6-22
SCALE
CHECKED BY
APPROVED BY
DWG. NO. 2-760

PLATE VII.

Test 26-1				Test 26-2				Test 26-3			
Time	CO_2	CO_2+O_2	CO_2+O_2 +CO	Time	CO_2	CO_2+O_2	CO_2+O_2 +CO	Time	CO_2	CO_2+O_2	CO_2+O_2 +CO
10:45	13.0			11:35	14.0	16.0	16.0	11:30	12.8	16.2	16.2
11:00	13.8	16.2	16.2	11:40	13.8			11.40	13.4		
11:04	12.2			11:45	14.0			11:45	13.4		
11:07	12.2			11:50	13.8			11:50	13.3		
11:10	12.0			11:55	13.9			11:55	13.4		
11:15	14.2			12:00	14.0	16.0	16.0	12:00	13.4		
11:20	14.0			12:05	14.3			12.10	13.2		
11:35	14.0			12:10	14.1	16.0	16.0	12:20	13.4		
11:40	14.1			12:20	14.2			12:30	13.6	16.4	16.4
11:45	14.2			12:25	14.2			12:45	13.4		
11:47	14.2	16.0	16.1	12:30	14.1			12:50	13.4		
11:55	14.0			12:35	14.3			1:00	13.4	16.2	16.2
12:07	14.0			12:42	14.4	15.9	15.9	1:05	13.6		
12:16	14.3			12:50	14.5			1:10	13.6		
12:20	14.2			1:05	14.4			1:15	13.6		
12:25	14.2			1:10	14.1			1:20	13.8		
12:35	14.2			1:15	14.1	16.0	16.0	1:25	13.8		
12:56	14.4			1:20	14.2			1:30	14.0		
1:02	14.2			1:25	14.3			1:35	14.4		
1:09	14.4			1:30	14.4			1:40	14.4	15.0	
1:15	14.0			1:40	14.5	15.7	15.8	1:45	14.7		
1:25	13.8			1:48	14.3	15.8	15.9	1:50	14.4		
1:30	13.8			1:50	14.3	15.8	15.9	2:00	14.0		
1:46	14.2			2:00	14.0	15.9	16.0	2:05	14.0		
1:51	14.3			2:10	14.1	15.9	16.0	2:15	14.0		
1:56	13.4			2:15	14.1			2:20	14.0	16.0	
2:02	14.0			2:20	14.2			2:25	13.9	16.1	16.1
2:10	14.2			2:25	14.1	15.9	16.0	2:30	13.9	15.9	16.0
2:30	14.1			2:45	13.6	16.2	16.2	2:35	14.3	15.8	15.8
2:51	14.0			2:50	13.7			2:43	14.6	16.0	16.0
2:55	13.8			2:55	13.8			2:50	14.2	15.9	15.9
3:10	14.2			3:00	13.8			3:00	14.3	16.0	16.0
3:25	13.4			3:05	14.0			3:15	14.1		
3:56	14.2			3:15	14.3			3:30	14.2		
				3:20	14.3			3:35	14.1		
				3:25	14.4			3:40	14.1		
				3:30	14.3	15.9	15.9	3:45	14.1		
				3:38	14.2			3:55	13.8		
								4:00	13.8		

PLATE VIII.

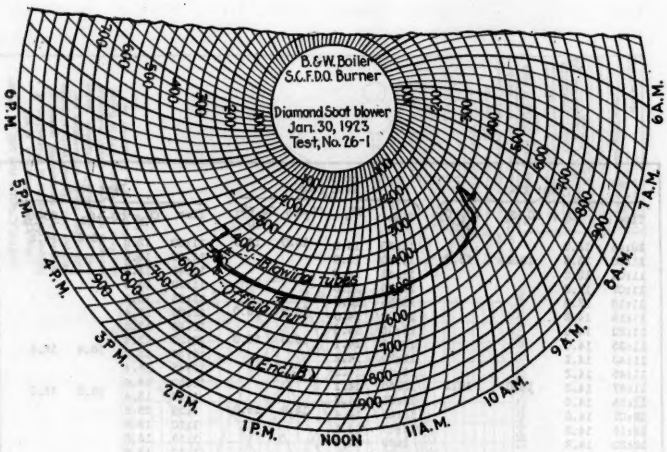


PLATE IX.

METHOD OF PROCEDURE.

Test 26-1. Prior to the first test which was run on January 30th, a crew of men with steam lances were put to work to clean the boiler heating surfaces as thoroughly as possible through the side cleaning doors. Every effort was made to reach all pockets and corners. Fires were lighted at 9:15 A. M. Plate IX shows that from 9:30 A. M. the stack temperature rose steadily until about 2 P. M., after which it remained constant at approximately 515 degrees F., when it was considered that boiler walls, baffles and setting were thoroughly warmed up. (This preliminary warming-up run was made prior to each test run.) The official run from 2 to 3:30 P. M. determined the evaporative efficiency of the boiler for this test. Immediately after the conclusion of the official run the soot blowers were used and the stack temperature thereby reduced to 490 degrees at 3:45 P. M., which temperature continued until 4 P. M. when the fires were shut down. During this official run evaporation was at the rate of 11,392 pounds

of water per half hour, the fuel being burned at the rate of 735 pounds per half hour. The average stack temperature was 514 degrees at an average open fire room temperature of 82 degrees F. Average gas analyses CO_2-14.0; O_2-1.97; CO-0. Boiler and furnace efficiency 82.81 per cent.

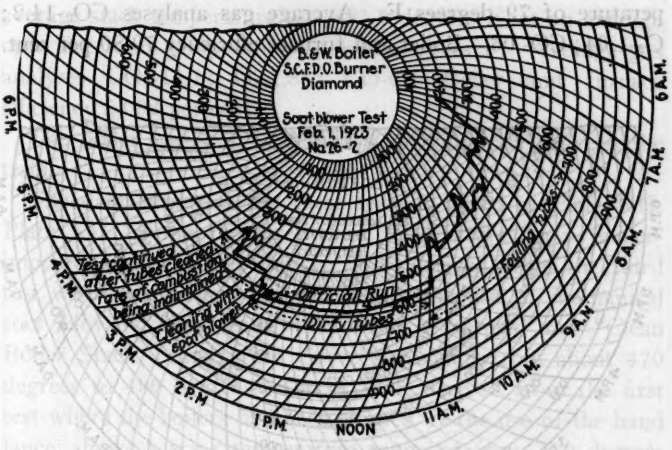


PLATE X.

Test 26-2. On February 1st, beginning at 8 A. M., the heating surfaces of the test boiler were purposely fouled by incomplete combustion until, at about 11:30 A. M., the stack temperature had reached approximately 570 degrees, at which point the temperature remained constant except for very slight variations each way. The official run from 12:30 P. M. to 2 P. M. determined the evaporative efficiency of the boiler for the test. At about 2:35 P. M. the mechanical soot blowers were operated and, in approximately seven minutes, the stack temperature had been reduced from 560 degrees to 480 degrees F. The test was continued and the same rate of combustion was maintained until about 3:30 P. M. at which time the fires were shut down. The temperature of 480 degrees

established by using the soot blowers remained constant from 2:50 until 3:30 P. M., when the fires were shut down. During this official run evaporation was at the rate of 10,887 pounds of water per half hour, the fuel being burned at the rate of 744 pounds per half hour. The average stack temperature was 574.6 degrees F. at an average open fire room temperature of 79 degrees F. Average gas analyses CO_2-14.2; O_2-1.64; CO-.06. Boiler and furnace efficiency 79.80 per cent.

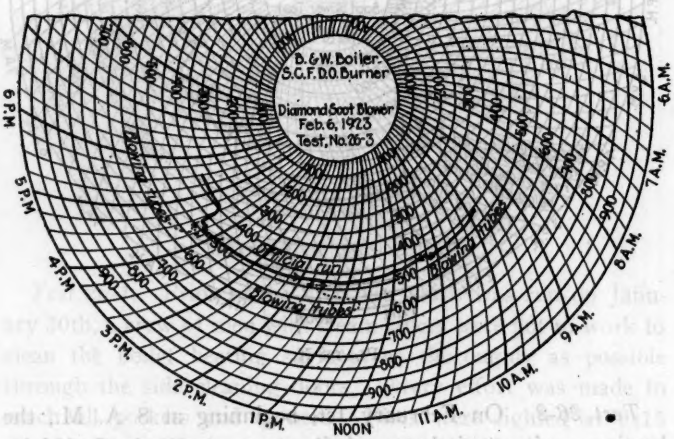


PLATE XI.

Test 26-3. Prior to beginning the official run on the third test, which was conducted on February 6th, the boiler heating surfaces were cleaned by using the mechanical soot blowers. From Plate XI it will be observed that between 11:15 and 11:30 A. M., and also between 2:30 and 2:45 P. M., while stack temperatures were at approximately 470 degrees F., the soot blowers were used without any appreciable reduction in stack temperature, indicating the clean condition of the boiler. The official run was from 2 to 4 P. M., terminating with a stack temperature of 490 degrees F. Immediately after the

termination of the official run the mechanical soot blowers were used, reducing the stack temperature to approximately 480 degrees F. at about 4:20 P. M., at which time the fires were shut down. During this official run evaporation was at the rate of 11,352 pounds of water per half hour, the fuel being burned at the rate of 749 pounds per half hour. The average stack temperature was 481.9 degrees F. at an average open fire room temperature of 80.4 degrees F. Average gas analyses CO_2-14.1; O_2-1.88; CO-0. Boiler and furnace efficiency 83.92 per cent.

The boiler was not used during the intervals between the tests.

The data summary for these tests is given in Plate XII. Plate XIII shows the three stack temperature curves superimposed on one sheet. Curve 26-3, derived from the third test where the boiler was cleaned by the use of mechanical soot blowers, represents what may be termed the "Clean Boiler Stack Temperature Curve"—varying from about 470 degrees to 490 degrees. Curve 26-1, derived from the first test where the boilers had been cleaned by the use of the hand lance, shows a stack temperature range of from 500 degrees to 520 degrees F. Curve 26-2, derived from the second test where the tubes were purposely fouled, and where the stack temperature varied from 560 degrees to 575 degrees F., indicates the dirty boiler performance. The efficacy of the mechanical soot blowers is graphically indicated by the manner in which their use after the termination of the first and second tests resulted in reducing these stack temperatures easily and promptly to about 470 degrees F.—the stack temperature which corresponds to the clean boiler.

The relative positions of these stack temperature curves correspond well with the boiler and furnace efficiencies for the respective tests.

Inspection of the fire side of the boiler tubes after cleaning by hand and by soot blowers was all in favor of the mechanical soot blowers which fairly scoured the tubes and reached the

Evaporative Tests on Babcock & Wilcox (Oklahoma Type) Experimental Battleship Boiler equipped with Diamond Power Specialty Corporation Soot Blowers and the Self-contained Draft Control Burners.

Water heating surface - 4000 sq. ft.	No. of tubes	792	22
Total heating surface - 4000 sq. ft.	Size of tubes	2" O.D.	4" O.D. circ.
Furnace volume - 445 cub. ft.	Diameter of steam drum - 36".		

Working pressure - 295 lbs. per sq.in., gauge.

1. Test number	26-1	26-2	26-3
2. Date	1/30/23	2/1/23	2/6/23
3. Duration of test	1-1/2 hr.	1-1/2 hr.	2 hrs.
4. Number of burners used	4	4	4
5. Size of atomizers	P.O.T.P. #49-20	P.O.T.P. #49-20	P.O.T.P. #49-20
6. Steam pressure on drum - lbs.per sq.in./G	200	200.5	200
7. Steam to burner turbines - lbs. per sq.in./G	50	45	45
8. Feedwater temperature of boiler - °F.	216.5	219.6	214.2
9. Water actually evaporated - lbs.per 1/2 hr.	11292	10887	11552
10. Oil burned - lbs. per 1/2 hr.	735	744	749
11. Oil pressure at burners-lbs.per sq.in./G	155	150	152
12. Oil temperature at burners - °F.	205.5	206.3	187
13. Fireroom temperature - °F.	82	79	80.4
14. Stack temperature - °F.	514	574.6	481.9
15. Fireroom pressure - in. of water	open	open	open
16. Air pressure in furnace - in. of water	0 to -.01	0 to -.01	0 to -.02
17. Air pressure at base of stack-in. of water	-.14	-.14	-.11
18. Smoke by Ringelman scale	1/4	1/2 to 1	1/4
19. Carbon dioxide - %	14.0	14.2	14.1
20. Oxygen - %	1.97	1.64	1.88
21. Carbon Monoxide - %	0	.06	0
22. Calorific value - B.T.U.s per lb.	18551	18551	18362
23. Factor of evaporation	1.0460	1.0425	1.0482
24. Actual evaporation per lb.of fuel - lbs.	15.186	14.633	15.152
25. Equivalent evaporation per lb.of fuel- lbs.	15.851	15.256	15.885
26. Oil burned per sq.ft.water H.S.lbs./ hr.	.3765	.3720	.3746
27. Oil burned per cu.ft.furnace volume lbs/hr.	5.38	5.35	5.37
28. Oil burned per burner per hour - lbs.	376.5	372.0	374.6
29. Baume' gravity of fuel	14.85°	14.85°	15.4°
30. Specific gravity of fuel	.9689	.9689	.9633
31. Boiler and furnace efficiency - %	82.81	79.80	83.82

PLATE XII.

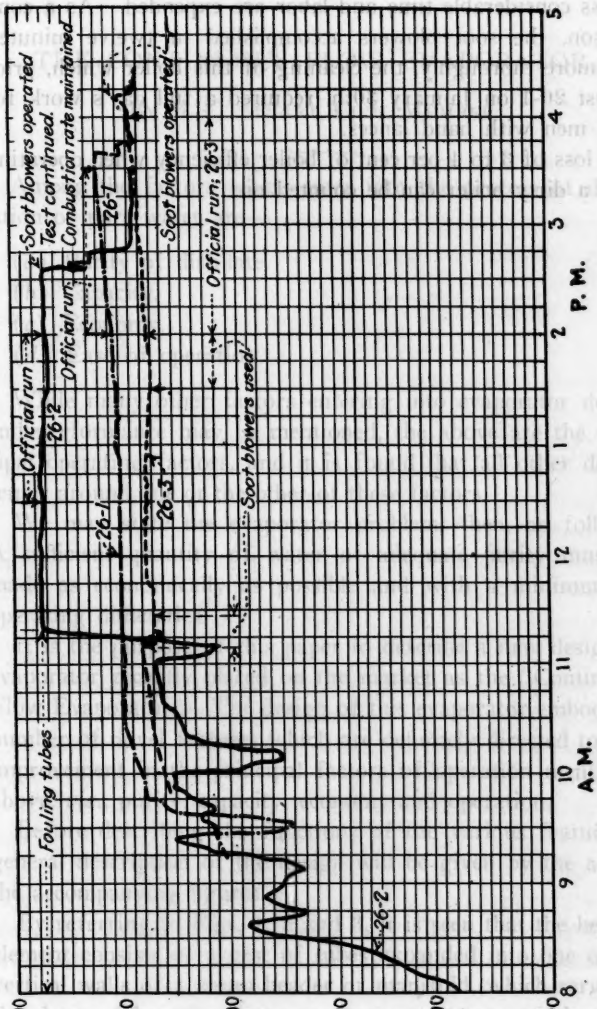
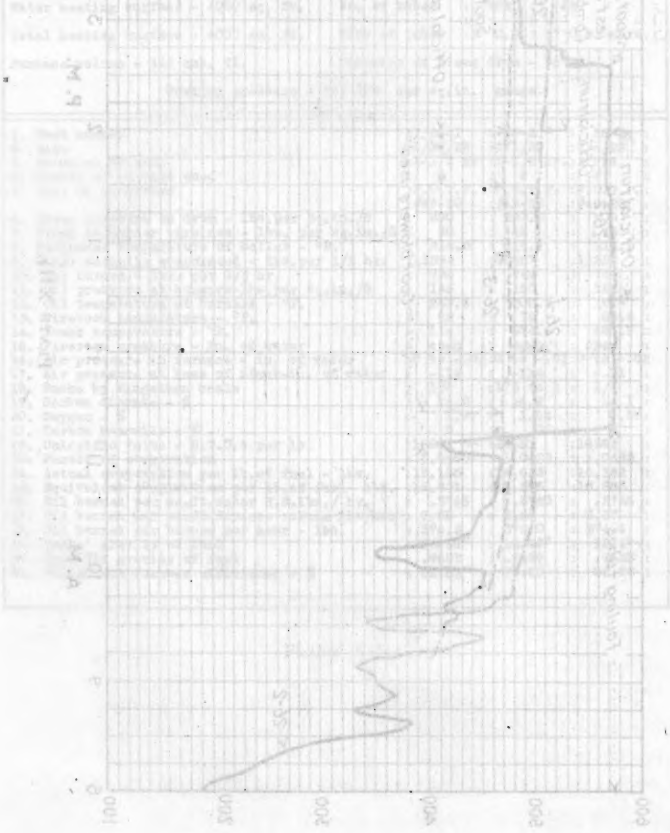

Soot blowers operated
Test continued.
Combustion rate maintained.
Official run
26-2
Official run
26-1
Soot blowers operated
Official run; 26-3
Soot blowers used
26-1
26-3
26-2
Fouling tubes
600
500
400
300
200
100
8
9
10
11
12
1
2
3
4
5
A. M.
P. M.

PLATE XIII.

pockets which the ordinary hand-cleaning does not accomplish unless considerable time and labor are expended. As a comparison, the soot blowers accomplished in twelve minutes, and more thoroughly, the cleaning of this boiler which, prior to test 26-1 on January 30th, required a full day's work for four men with hand lances.

A loss of 3 to 4 per cent of boiler efficiency when operating with a dirty boiler can be counted on.



THE CONTINUOUS FLOW EVAPORATOR.

By M. C. Stuart, Civil Member.

Among the factors which enter into the process of distillation of pure water are—

(*a*) Purity of distillate.
(*b*) Capacity.
(*c*) Economy.
(*d*) Ease of operation.

While many other factors entering into evaporator design and performance may be mentioned, the above are the principal operating factors, and it is found that all other details center around one or the other of these factors.

We may state the evaporator problem, then, as follows: A sufficient quantity of water of adequate purity must be made as economically as possible and with a minimum of operating difficulties.

It is the purpose of this paper to describe a new design of evaporator recently placed on the market as the "Continuous Flow Evaporator." The design of this evaporator embodies a number of novel features which are definitely directed toward improvement in the principal factors of operation mentioned above, *viz.*, purity, capacity, economy and operation.

Before describing the functions of the various features, a general description of the design will be given by the aid of the accompanying figures.

By referring to Figs. 1, 2 and 3, it is seen that the heating element consists of a nest of tubes expanded into one of the vertical walls of a steam header or manifold, which serves as the door. The tubes have a reverse curvature as shown in Figs. 1 and 4. The outlet of the tubes enters the manifold at

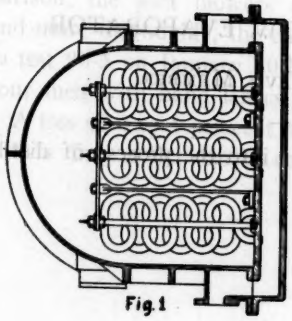


Fig.1

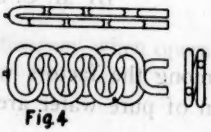


Fig.4

Fig.5

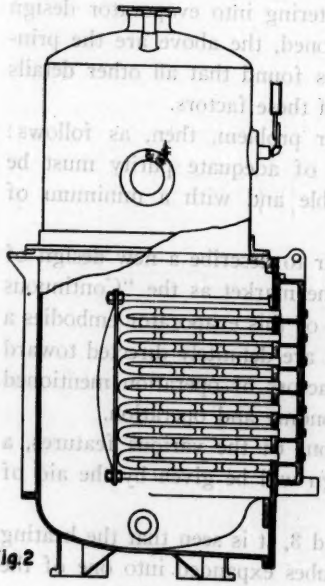


Fig.2

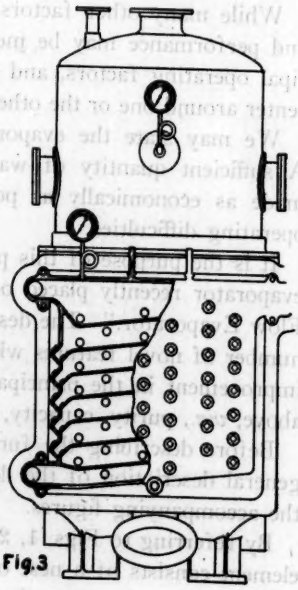


Fig.3

a lower level than the inlet, and in all cases a partition in the steam manifold separates the inlet and outlet openings. This serves to place a vertical bank of tubes in series arrangement, for example in Fig. 3 we have seven tubes in series. The steam enters at the left of the top row of tubes, Fig. 3, and after passing through the top row of tubes where part of the steam is condensed, it returns to the second horizontal compartment in the steam manifold, and enters the second row of tubes. It is a feature of the design that all tubes are supplied with dry steam, that is, condensate from one tube does not flow through the next lower tube. To this end a series of drain orifices are provided, one at the extreme left of each manifold space. The design of these orifices is shown in detail in Figure 5. The drain orifice consists of a small hole drilled in a plug screwed in the drain pocket of the steam manifold, and it is located directly in line with a stop plug above, by the removal of which the orifice plug may be easily inspected, cleaned or removed. The size of the orifice may be easily computed to pass just the amount of expected condensate coming into the manifold space which it serves; but no concern need be felt if the orifice is slightly over size, for a simple computation based upon the laws for the flow of water and steam through orifices shows that, with the same pressure head, the flow of steam through a given orifice will be only about the one-hundredth part of the flow of water. That is, as the orifice is designed it passes all the condensate, but only a minute quantity of steam under any conditions. It is well recognized that heat transfer from steam to a metal tube is facilitated by high steam velocity and absence of water at the tube surface. Placing of the tubes in series gives high steam velocity, and the provision for draining the condensate in each steam space prevents the accumulation of water in the lower tubes. The action may be described as continuous high velocity flow of steam, with progressive drainage and removal of condensate. The continuous flow principle plays a further important part in the design, which will be

referred to later. A drain orifice is provided in the partitions between all successive manifold compartments except the last two. All the condensate from the upper coils must pass through the lowest coil. This insures the condensation of all the steam, and provides some additional cooling of all the condensate.

The construction of the tube nest and steam manifold for the second effect is shown in Fig. 6. This is similar to the

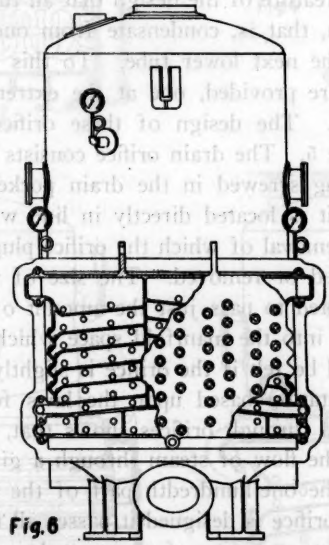


Fig. 6

first effect with one important difference. The steam manifold has a vertical division wall extending from the top to the bottom which divides the manifold into two distinct sections. The left section of coils is proportioned to receive only the vapor from the first effect, while the right section is designed to receive exhaust steam from auxiliary machinery, live steam at reduced pressure, or vapor from the first effect. The coil drain from the left hand section, con-

sisting of first effect vapor condensate, will always be entirely free from oil or other foreign contaminating substances liable to be found in exhaust or live steam, and will therefore be most suitable for drinking water.

It has been found that if one set of coils is used alternately for oily exhaust steam and first effect vapor, that the coils become coated with oil, and traces of oil are always present when drinking water is being made. It is noted that in this design, first effect vapor may go to the left hand coil section of the second effect, to the right hand section or to both. But live or exhaust steam can go only to the right hand section. Best economy is obtained when the first effect vapor goes to both sections, if exhaust steam is not available.

The arrangement of the evaporator in double effect may be seen in Fig. 7. Steam entering the first effect coils is controlled by a special micrometer valve, which admits to the coils any desired definite amount of steam, regardless of the condition of the coils. With the coils clean, as upon starting up, the coil pressure will be low, and will automatically reach and maintain such a value as is required to condense just the amount of steam admitted to the coils by the micrometer valve. As scale forms on the coil, the coil pressure rises until a new equilibrium condition is reached under which the constant amount of steam admitted to the coils by the valve is condensed. This results in a constant capacity, regardless of coil conditions, because the condensation in the coils of a constant quantity of steam results in the evaporation of a constant quantity of vapor.

The theory underlying this method of production of constant capacity is given in an article in the February, 1919, issue of the Journal of the AMERICAN SOCIETY OF NAVAL ENGINEERS entitled "An Improved Method of Operating Evaporators." In that article results of extensive tests are given to illustrate the operation of the principle, and subsequent application in practice has shown the method to be entirely practicable.

As the steam passes through the coils in series, the condensate is progressively drawn off by means of the orifice drains, as previously described; and there is a gradual decrease in steam pressure along the coil, due to friction drop of the flowing steam. The drain from the lowest coil of the first effect does not go to a trap as in usual practice, but passes over to a series of coils in the low pressure shell, so that the high temperature drain from the first effect coils is circulated through the water space in the second effect shell, where a further amount of heat is abstracted from the drain. These drain coils may be seen in Fig. 6, where the five coils of the lowest horizontal row of coils are shown arranged in series. After passing through these coils the pressure and temperature of the first effect coil drain have both been sufficiently reduced so as to dispense with the necessity of a trap to prevent loss of live steam. The drain may now be led directly to the feed tank, to a feed heater, to a condenser, or to the atmosphere, without any attention whatever, and without the possibility of blowing steam through. It would be impossible for any live steam to get through the long passages of the low pressure drain coils without being condensed and cooled. The absence of the necessity for a trap on the high pressure coil drain removes one of the troublesome features of operation, and at the same time improves economy greatly by preventing waste of live steam, and effecting a low temperature for the condensate. This feature also prevents air binding in the coils, as all the air can flow out freely with the water. With a trap, no air can get past the trap valve, but must be removed by bleeding, with an accompanying waste of steam.

The drain from the second effect coils may likewise be passed through a feed heater and discharged directly to the fresh water tank or to the distiller condenser.

Having described the general features of the design, it will be well to make a systematic study of the four factors

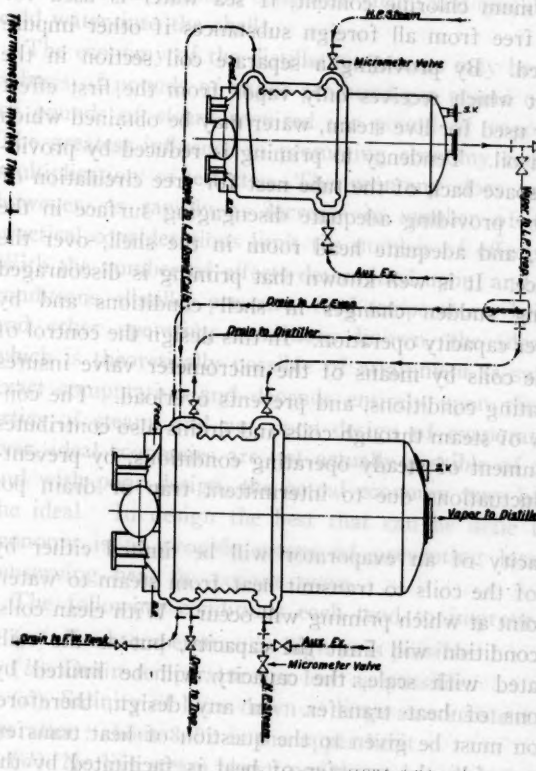

H.P. Steam
Micrometer Valve
Vapor to Distiller
Aux. Ex.
Drain to L.P. Coils
Drain to Distiller
Vapor to Distiller
Aux. Ex.
Micrometer Valve

FIG. 7.

of operation mentioned at the beginning of the article, and notice wherein the design attempts to meet the requirements of these factors.

First, as to purity of distillate. To meet the requirement as to purity, the distillate must be free from oil, and have a certain minimum chlorine content, if sea water is used for feed, or be free from all foreign substances if other impure water is used. By providing a separate coil section in the second effect which receives only vapor from the first effect and is never used for live steam, water may be obtained which is free from oil. Tendency to priming is reduced by providing a large space back of the tube nest for free circulation of brine, and by providing adequate disengaging surface in the water space, and adequate head room in the shell, over the water surface. It is well known that priming is discouraged by preventing sudden changes in shell conditions and by avoiding over capacity operation. In this design the control of steam to the coils by means of the micrometer valve insures steady operating conditions, and prevents overload. The continuous flow of steam through coils and drains also contributes to the attainment of steady operating conditions, by preventing wide fluctuations due to intermittent trap or drain pot action.

The capacity of an evaporator will be limited either by the ability of the coils to transmit heat from steam to water, or by the point at which priming will occur. With clean coils, the latter condition will limit the capacity, but as the coils become coated with scale, the capacity will be limited by considerations of heat transfer. In any design, therefore, consideration must be given to the question of heat transfer. On the steam side, the transfer of heat is facilitated by the continuous flow principle, and by progressive drainage of condensate, as previously described. On the water side provision is made for the automatic removal of scale by the peculiar shape of the tube. Each tube is made up of a series of reverse loops, and the tubes are rigidly supported at front and back.

When the tube changes length with sudden change of temperature, the curvature of the loops change with consequent loosening and removal of the scale. For the purpose of cracking off the scale, sudden change in temperature is brought about by filling the shell with cold water and quickly admitting steam to coils or filling coils with steam and quickly admitting cold water into the shell.

The economy of the distillation process may be stated upon a basis of pounds of vapor produced per pound of steam; or of pounds of steam required per pound of vapor produced. The greatest influence in promoting economy consists in the multiplication of effects. The economy does not improve, however, as rapidly as increase in number of effects, and practical considerations limit the number of effects employed. With the number of effects determined upon, and with steam conditions, distiller pressure, feed temperature, brine density, and other operating conditions known, the ideal economy which is theoretically possible of attainment is subject to an exact computation and depends entirely upon thermal properties of steam, and not upon design of evaporator. However, ideal economies are not actually possible of attainment, and with poor design, the actual economy may be far from the ideal. In design the best that can be done to promote economy is to provide means of preventing losses and of conserving heat in various ways.

The following conditions each tend to improve economy:

(*a*) Feed temperature as high as is possible.

(*b*) Drain temperature as low as possible.

(*c*) Salinity of blow down as large as consistent with good operation; about 3/32 is the upper limit.

(*d*) No live steam blown out through coil drain.

(*e*) Prevention of priming with consequent loss of salted or contaminated distillate.

(f) Reduction of radiation loss to a minimum.

In making this design, all of these conditions were kept in mind. The continuous flow principle, with sub-cooling of

drain in the shell of the lower effect, and final cooling of drain in feed-water heater, produces a drain temperature as low as possible, and within a few degrees of the cold feed temperature. By passing feed first through the drain heater, then through a vapor heater, a high feed temperature is produced. The continuous flow principle prevents loss of steam through drain, and also rids the system continuously of air.

The features of usual evaporator operation which require the closest attention are maintenance of proper coil pressure, shell water level, brine density and drain pot water level, and the bleeding of air from the coils. Automatic regulators of water level and brine density have not met with general acceptance. In usual practice the coil pressure is sometimes controlled by hand and sometimes by a reducing valve. Drain conditions are regulated by means of a trap, or a drain pot with a sight glass, in which the water level is maintained with a hand operated valve. The possibilities for losses of steam through the drain in ordinary operation are great. In the continuous flow design, due to the complete condensation of steam before reaching the outlet, there is no possibility for loss and no attention is required. It is essential, however, to maintain a proper water level in the shell, as in all evaporator operation.

The micrometer valve on the steam inlet takes care of coil pressure and steam flow automatically, without the necessity for reducing valve or hand control of coil pressure. All other operating conditions are also kept steadier by this device.

Tests of a preliminary design show that the essential features of the design are practical. In single effect an economy of 1.178 pounds of steam per pound of distillate was obtained, and in double effect the economy was .685 pound of steam per pound of distillate. The feed temperature was 45 degrees F. The maximum capacity was 170 gallons per 24 hours per square foot of coil surface, with a chlorine content of less than one-half grain per gallon.

Summing up, it may be said that the continuous flow evaporator is the result of a deliberate effort to produce an evaporator which will distill water of certain purity, at a definite desired rate, with an economy as close as possible to that ideally obtainable, and with new features of simplicity of operation.

A MATHEMATICAL CHART.

By E. L. Rice.

The accompanying chart is divided into four sets of lines; namely, slant lines, which are factors, and may be divisors, angles, quotients, denominators, decimal equivalents, or other factorial elements; radial lines, which are also factors and may perform substantially the same functions as the slant lines; vertical lines, which may be used as products, dividends, lesser sides of triangles, numerators, the lesser denomination in all conversions, and other functions; two curves running from one lower corner to the other, the upper curve being the cube root curve, which is used to obtain cubes and cube roots, and the lower curve, the square root curve, which is used to square numbers and to extract square roots.

Each of the three sides of the chart is divided into tenths and hundredths, and the slant side and base of the chart are also divided into two-hundredths. The degrees along the left side, under "H," run from 6 to 85, and are divided into ten degrees and unit degrees up to 65. Along the base of the chart the degrees run from 6 to 44, and are divided into tens and units. The heavy black lines dividing each side of the chart into tenths, are one one-hundredth wide, and are designated by large numbers set in circles; the thin white lines run through the middles of the heavy black lines to the point itself.

DECIMAL EQUIVALENTS.

To find the decimal equivalent of, for instance, ⅘ths; notice the big 4 at the top of the chart and where the vertical line from big 4 crosses the radial line from the big 5, notice that it crosses on the slant line 8. Therefore, ⅘ths is .8 or .80. Again notice where the vertical line from the big 3 crosses the radial line

from the big 4 which is at the slant line midway between 7 and 8 and we observe that the decimal equivalent of ¾ths is .75. (Fig. 1.) Assuming now that we have a problem involving 64ths. That is to say, we desire to know the decimal equivalent of, say, $^{52}/_{64}$ths; we follow the vertical line from 52 until it crosses the radial line from 64, which is between 6 and 7, and then we follow the slant line from the intersection of these and we see at a glance that it is .81; thus at a glance we have any decimal equivalent.

DIVISION.

To divide, follow the vertical line, which is the dividend, and locate where it crosses the given sum as a divisor, which may be either the slant or the radial, and read the quotient upon either of the two factor lines; that is to say, if the divisor is the radial, read the quotient upon the slant, and if the divisor is slant, read the quotient upon the radial. (Fig. 2.) Thus, given a simple problem for illustration of 56 divided by 8. Notice the diamond midway between 5 and 6 and next to this at the right, the line from the 6 point which is the line representing 56. Follow the vertical line from this to where it crosses the slant line 8 and we notice that it is exactly on the radial line 7, and therefore the answer or quotient is 7. (Fig. 2.) Now if we wish to divide 565 by 8, we simply read a little further over, midway between the 6 line and the 7 line and see that our quotient would be substantially 70.6.

MULTIPLICATION.

In multiplication we reverse the process of division. That is to say, the vertical is the product and the slant and radial are the two factors. It is immaterial whether we use the radial or the slant for the multiplier, although it is preferable to read the factor having the greater number of digits from the top, as the graduations are both wider and more easily read by reason of the legends at the ends of the lines. Thus in multi-

plying, all that is necessary is to find the intersection of a slant and radial representing the two numbers, and read the product upon the vertical. For instance, 8 radial crosses 7 slant at 56 vertical. (Fig. 3.) Again, if we have two digits to each number, say 45 times 45, we find that the two cross nearly upon the vertical 2 line, and our answer is approximately 2,000 or exactly 2,025. Now if we have 455 multiplied by 45, we perform the operation in two steps. In the first step we multiply the given numbers and read the product as approximately 20,400, since we can read the first three digits correctly from the chart. In the second step we multiply the last two digits of each of the given numbers, that is, we multiply 55 by 45, and read our answer as 2,475, since we can read the first three digits correctly and we know that our last digit is 5, because the last digit of each of our factors is 5. Then the last two digits of this second product are the correct fourth and fifth digits of our first product, so we know that 455 multiplied by 45 equals 20,475. (Fig. 4.)

ADDITION OF FRACTIONS.

In addition of fractions we first determine the decimal equivalents as shown above, and simply add the equivalents determined. For example, to add $^{52}/_{64}$ths and $^{52}/_{65}$ths, we find that these fractions expressed as decimals are, respectively, .812 and .80, and adding these, we know the sum is 1.612. (Fig. 6.)

SQUARES.

In order to square a number, follow either a radial line or a slant line until it crosses the square root curve, that is to say, the lower curve. Thus to square a number, as for instance 5 squared, follow either the slant 5 or the radial 5 to the lower curve and it is found that they cross on this curve; by following the vertical line through this point of intersection we find the square of 5 to be 25. (Fig. 7.) Naturally if 51 is to be squared we find where the 1 line after the large 5 crosses the

square curve; and if 515 is to be squared, we find where the line midway between the lines 1 and 2 following the large 5, crosses the square curve and follow the vertical through this point to find the answer.

SQUARE ROOTS.

If we desire to extract the square root, we reverse the process; for example, assuming that we desire to extract the square root of 25, we follow the vertical from the diamond midway between the large 2 and 3, to where it crosses the square root curve and we read the answer of 5 either on the radial or a slant. (Fig. 8.) If we desire the square root of 2,550, we follow the vertical 2,550 which is found midway between the 5 and 6 lines following the large 2, to where it meets the square root curve and read the radial through this point for the answer.

It will be noted at this time that there are two different square roots of every like set of digits; that is, 25 has one root, 2.5 has another root, which are entirely distinct. The roots where two digits are involved, are read from the graduations to the right of large 1. Thus the square root of 20, would be at a glance, 4.5; that is, we determine this by following the vertical from the large 2 at the top of the chart, to the square root line. On the other hand, the square root of 2 would be 1.41. We determine this by following the vertical from the 2 line between zero and large 1 at the top. To find the square root of 9, follow the vertical from the 9 line to the left of the large 1 to where it meets the square root curve and the answer is read on the slant as 3. (Fig. 9.) In the same manner we can find every square root by dividing the given number into sets of two digits in the old system of extracting the square root, but a simple rule is here given.

RULES FOR SQUARE ROOT.

If the number has an even number of digits the big graduations are used; that is, if we desire the square root of 4,555, we locate it between 4 and 5 in the big circles, but if the number

has an odd number of digits, the graduations to the left of the large 1 are read. For example, to find the square root of 455.5, we locate the vertical line between the 4 and 5 lines at the left of the 1 in the large circle.

CUBES.

To find the cube of a number follow the slant line of the given number until it crosses the cube curve, which is the upper curve, and follow the vertical line for the answer. Thus the cube of 5 is found by following the slant line 5 until it crosses the cube curve, and reading the answer of 125 on the vertical line. (Fig. 10.) Thus to cube a number, follow the slant of the number to the cube curve and read the vertical line. Do not try to cube or extract the cube root by reading the radial. Either the radial or the slant can be used for the square and square root, but not for the cube and cube root.

CUBE ROOTS.

In cube roots, separate the number into groups of three digits, beginning at the right, and if the left hand group has three digits, then follow a vertical at the right of the big 1 until the vertical crosses the cube line and the slant gives the answer; if the left group has two digits, locate the vertical line to the left of the big 1; if there is but one digit in the left hand section, the vertical line is located between zero and the 1 line to the left of big 1. To find the cube root of 216 we locate the vertical between lines 1 and 2, to the right of large 2, and follow it until it crosses the cube curve; then we follow the slant through this point and find the answer to be 6. (Fig. 11.) Thus to extract the cube root of a number, follow the vertical of the number to the cube curve, and read the slant. To find the cube root of 64, in which two digits are involved, locate the vertical line between lines 6 and 7, to the left of large 1, follow it until it crosses the cube curve, and read the slant line to obtain the answer, which is 4. (Fig. 12.)

HIGHER POWERS.

Numbers can be raised to higher powers by combinations of the square curve and the cube curve. For example, to raise a number to the sixth power, follow the slant of the number to the cube curve, follow the vertical from this point to the top, then follow the radial from this last point to the square curve, and follow the vertical to the top, where the answer may be read. To raise 8 to the sixth power, for instance, follow the slant from 8 to the cube curve, follow the vertical from here to the top, follow the radial from the top to the square curve, and read the vertical through this point to obtain the answer, which is approximately 262,000. (Fig. 13.) Thus the operation of raising a number to the sixth power for instance, is practically instantaneous. To raise 5 to the fourth power, follow the slant of 5 until it crosses the square curve, follow the vertical through this point to the top, follow the radial from the top to the square curve, and read the vertical through this last point to obtain the answer which is 625. To raise 5 to the fifth power, perform the same operation as to raise it to the fourth power, and then follow the radial from the last point found, that is, from 625, until it crosses the slant line 5 and read the vertical which is approximately 3,120.

MULTIPLE OPERATIONS IN ONE.

Multiple operations may be combined in this manner until many operations can be carried out at a single glance. Another problem that is easily solved, for instance, is one in which the circumference of a circle is to be found. This is done by following either the radial or the slant line of the diameter to the π line, and reading the circumference on the vertical line; either the radial or the slant may be used for the diameter, since π is shown on both radial and slant lines. (Fig. 15.)

INTEREST CALCULATIONS.

The interest on any given sum of money at a given rate of interest is a multiple operation and requires generally consider-

able calculation to accurately determine it. On this chart, it is solved at practically a glance. To find the interest for ten months on $55 at 8 per cent. Ten months would be ⅚ of a year, so we would locate the intersection of vertical 5 and radial 6 and then follow the slant through this intersection until it crossed the radial 8, follow the vertical from here to the top, run down the radial from the top to the 55 slant, and read the answer on the vertical through this last point, the answer being $3.66. (Fig. 29.)

MULTIPLICATION AND DIVISION OF FRACTIONS.

The rapidity with which complex fractions can be multiplied and divided on this chart is amazing. *To multiply simply read the vertical from the intersection of the decimal or fraction value lines.* That is to say, as shown in the little diagram at the upper right hand corner of the chart, the value of every fraction is represented by a slant line which in this diagram is called "Decimal of Fraction Value Line." No matter where you are on that line, that line is the value of the fraction whose numerator and denominator cross on that line. This being a slant line it is a factor line, and a factor line which crosses another factor line, multiplies the two factors. Therefore if you have two fractions, you can see at a glance the decimal lines which represent the values of the fractions. It is preferable to form the habit of reading fractions with the vertical line for the numerator and a radial line for the denominator, which gives a slant for the decimal. In this case, however, the decimal lines will be slants. Since slant lines are parallel and do not intersect or cross each other, then one of the slants should be made a radial line, which is done on the square curve. Thus, the radial line and the slant line of the same value meet on the square curve, because a square root is the same number multiplied by the same number, so that by running a slant line to the square curve and following the radial line which continues from this slant line, we have a continuous factor line of the

same value transferred from a slant to a radial line. Therefore to multiply fractions, we follow the decimal line of one fraction over the square curve to where it intersects the slant of the other decimal, and the product is read from the intersection of this radial and slant.

To divide a fraction: we transfer the dividend fraction decimal to a vertical which is done by following the line to the base of the chart where it continues upward in a vertical line. The intersection of this vertical with the decimal of the other fraction locates the radial quotient of the two fractions.

See Figures 27 and 28, which illustrate the transfer of factor on the square curve and also the multiplication of a simple fraction.

METRIC CONVERSION.

It will be noted that there is a dotted line just at the left of large radial 4. This dotted line is really 39.37. A simple rule for metric conversion is to read the meters or centimeters along a slant line to where it crosses the dotted metric line, and read inches on the vertical through this point. (Fig. 16.) For example, 75 cms. would be the slant midway between 7 and 8, and following this 75 line to where it crosses the dotted metric line, we read the vertical as 29.5 inches. In the same manner, 90 cms. is found to be roughly 35.4 inches. Reading backwards, if a number is given in inches and it is desired to change it to centimeters, as for instance, 30 inches, read the vertical 30 until it crosses the dotted metric line, and read the slant for cm. The whole scale of cms. is instantaneously given, as equivalents, which if in table form, would be a great many pages.

OTHER CONVERSIONS.

The general rule for all conversions is to read the lower denomination or the greater number on a vertical line, read the higher denomination or the lesser number on a slant line, and locate the conversion factor on a radial line. (Fig. 17.)

The conversion factor is the number of times the lower denomination is contained in the higher denomination. For example, there are 144 sq. in. in 1 sq. ft., so 144 is the conversion factor; to change sq. in. to sq. ft., locate the 144 radial line between lines 4 and 5 to the right of large 1, read the sq. in. along the vertical until it crosses this radial line and the sq. ft. may be read on the slant line through this point; to change sq. ft. to sq. in., read the sq. ft. along a slant line to where it crosses the 144 radial line and read the sq. in. on the vertical through this point. (Fig. 18.) In this manner, all other conversions may be made, as for instance, ounces to pounds. (Fig. 19.)

PROPORTION.

In proportion, if we have, for instance, the problem $2:4::3:6$, we know from Arithmetic that the product of the means equals the product of the extremes; that is, the product of the two inside numbers equals the product of the two outside numbers. If the unknown quantity in the problem is one of the means, follow the slant line of one extreme until it crosses the radial of the other extreme, follow the vertical through the point to where it crosses the slant of the known mean and the unknown quantity may be read on the radial line through this last point. If the unknown quantity is one of the extremes, follow the slant of one mean to where it crosses the radial of the other mean, follow the vertical line through this point to where it crosses the slant of the known extreme, and the unknown extreme may be read on the radial through this last point. In other words, the intersection of the slant and radial lines representing the means, falls on the same vertical line as the intersection of the slant and radial lines representing the extremes. For example, to determine the unknown quantity x in the proportion $2:4::3:x$, follow the slant 4 to where it crosses the radial 3, follow the vertical through this point to where it crosses the slant 2, and read the radial through

this last point to obtain the answer, which is 6. (Fig. 5.) Therefore, *the simple rule for proportion is the means and extremes intersect on the same vertical.*

ALGEBRAIC EQUATIONS.

Algebraic equations are solved at a glance as well as proportion. That is to say, find the decimal or fraction value line which is intersection of the slant of the numerator on one side of the equation with the radial of the denominator on the other side of the equation and the vertical through this intersection will be the line on which the slant and radial lines of other elements of the equation interest: thus $\frac{3}{8}$ equals $x/8$. 3 and 8 intersect on the vertical 24, 6 intersects on the vertical 24 at 4, therefore 4 is x. If given several quantities as the numerator or denominator on either side of the equation, these are quickly reduced as in other multiple operations above described and when the factor line representing their reduction is found, the crossing of this factor line with the factor line of the same reduction of the opposite element on the other side of the equation, falls on the same vertical as the intersection of the other elements of the equation. Thus simple algebraic equations are solved at a glance and very complex algebraic equations can be solved with a little practice, at practically a glance. *All algebraic equations are dissolved as follows: Reduce each side to a decimal line and apply rule for proportion.*

GEOMETRY.

A circular surface is defined in square units at a glance. To convert it into a solid, the eye continues to follow the line to its intersection of the third dimension factor. By a use of the square and cube curves and the multiple-operation-in-one principle shown in Arithmetic, all geometric solutions are had with remarkable rapidity. In some cases they are as fast as you can say the answers. As, for instance, diameters are read

on the slant, and circumferences on the vertical line. (See especially Figs. 15, 17 and 18.) That is to say, the eye merely locates the line on the slant representing say the diameter, and follows this line as a vertical to the top of the chart. The line bends at the 3.1416 line. The chart is so arranged that all lines continue. Thus, at the top of the chart a vertical line continues downward as a radial. At the bottom a slant continues upward as a vertical. On the square root curve a slant factor continues as a radial factor. On any conversion factor line the slant continues as a vertical. Just jump on a line and ride it, as it were, until you have reached the end of your desired calculations. You do this with the eye. Preferably the eye follows a heavy line nearest the point, bearing in mind that it is so many smaller lines from this heavy line. Thus at a glance take the area of a circle shown in Fig. 14. The radius being 8 inches, the eye follows the 8 line to the square root curve, where it intersects the thin vertical line to the left of the heavy vertical line. The heavy vertical line is followed by the eye to the top, then down its radial continuation until it reaches the π or 3.1416 line, and the line at the left of this heavy line crosses π on the vertical 2. At a distance the answer is read as 200 square inches; closer it is read as 201 square inches.

The above reading on multiple-operations-in-one, rapid as it is, is but a start in the speed on this chart. Note the tiny diagram in Fig. 14. Compare this with the large diagram on the chart which names the cube and square curves. It will be seen that the vertical cuts the square curve on the same slant as its radial continuation cuts the cube curve, or, in other words, going up a vertical from the square curve and then down the radial continuation of the vertical brings us to the cube curve on the same factor from which we started. Therefore we can start the factor line on the cube curve and eliminate two of the three steps, and reduce our line-following to a third. Thus, in this problem of radius squared times π, we simply follow the

radial from the cube curve to the line and read the vertical. Therefore, A times B squared would be the intersection of slant A with the radial from the intersection of the cube curve and slant B.

TRIGONOMETRY.

Every angle may be made into a right triangle by adding another side. The same angle has the same relation between its sides no matter how far the angle or how great the length of its sides. Thus, if we could tie a string to the top of the Washington Monument and could stand at a distance from the monument and pull this string straight, then the string would be a straight line from where we stood to the top of the monument. If we were to fasten this string to the ground and were to tie a thread with a weight on it to any point on our string, so that the thread would touch the ground, the thread would bear the same relation to the length of the string to where the thread is tied, as the height of the monument bears to the whole length of the string. No matter how many threads we dropped, they would all bear this same relation to this string. This is the basis of trigonometry, that is to say, the relation between all sides of a triangle having the same angles, is the same no matter how great the sides may be. In other words, the relation betwen the sides varies only with the changed angles. Therefore every angle has a different relation between the sides. Thus, at 30 degrees the height of the monument would be just half the length of the string. Now look at the left hand side of the chart and you see just even with the slant line 5 (the big 5 in the big circle) the figure 30 degrees. This means that the relation between the height and the longest side of a 30 degree angle is .5, or that the hypothenuse or longest side is just twice the altitude. Therefore, if the height of the monument is 550 feet, the string would be 1,100 feet long. If the length of the thread we dropped to the ground had been 35 feet, it would have been

70 feet from our hand. Let us now solve this on our chart. Glance down the vertical 35 until it crosses the slant 5 (which the chart says is the same as 30 degrees) and we find that the 35 vertical and the slant 5 cross on the 7 or 70 radial line. Then we learn this: that the vertical is the lesser side and the radial the greater side, and the slant the angle. Work out several problems to be sure you understand this. Try one in which the shorter side is given together with the angle and read the greater side upon the radial. Then try one in which the two sides are given and read the angle on the slant. Now you can solve the following problems: Given the altitude and angle, you can find the hypothenuse. Given the hypothenuse and angle, you can find the altitude. Given the hypothenuse and altitude, you can find the angle. Suppose now you wish to find the base from the altitude. You simply use the angles at the base of the chart instead of at the left of the chart. That is, if the base is given or wanted, you use the base angles or angles in line with the big "B" at the right of the chart, and if the hypothenuse is given or wanted, you use the angles in line with the "H" at the left of the chart. Thus the angles at the base of the chart are the relation between the base and altitude at that given angle. That is, a 27 degree angle (which you note is at the base just about on the 5 line) has an altitude substantially a half of the length of the base. Then if the altitude were 35 feet and the other given side were 70 feet, the angle would be shown at the intersection of the vertical 35 with the radial 70, which would be 30 degrees if the hypothenuse were 70 feet, and about 27 degrees if the base were 70 feet.

The way this is done in trigonometry is to consult a table and find the relation between the sides at the given angle, and then multiply the given side by this relation to find the other side. This chart carries this relation as a factor, and automatically consults the table and does the multiplying.

RIGHT TRIANGLES.

A simple rule to remember in right triangle calculations is that the vertical is the lesser side and the radial is the greater side, and the angle is read upon the slant line through the intersection of the vertical and the radial. (Fig. 20.) In solving right triangles, the degrees at the left of the chart, under "H," are used if the hypothenuse is involved either as a given or a desired quantity, and those along the base of the chart, under "B," are used when the base of the triangle is involved. When both the base and hypothenuse are involved, the graduations under "H" are used, and the angle read is subtracted from 90 degrees to obtain the angle included between the base and hypothenuse of the given triangle. It makes no difference which two sides of a right triangle are given, first observe which is the greater and which is the lesser side, follow the vertical of the lesser until it crosses the radial of the greater, and the slant line through the point of intersection gives the angle. If the angle is determined from the "H" scale, as described above, it is the angle between the base and hypothenuse of the triangle; if determined from the "B" scale, it is the smallest angle of the triangle. If the angle is given and the greater side is given follow the radial of the greater side until it crosses the slant of the angle, and the vertical will give you the lesser side.

Thus given any one side and an angle, another side is instantaneously read, and given any two sides the angle is found at a glance. A few problems to illustrate: Given a base of 4 and an altitude of 3, find the smallest angle of the triangle; follow the vertical 3 to where it crosses the radial 4 and follow the slant from this point to the scale at the bottom of the chart, since in this problem the base of the triangle is involved, the angle is then found to be approximately 37 degrees. (Fig. 21.) On the other hand, if these two given sides were the altitude and hypothenuse, we would read the slant to the left and determine the angle as approximately 49 degrees. (Fig. 22.)

Given again, an altitude of 3 and an angle of 37 degrees, to find the hypothenuse we follow the slant from 37 degrees on the scale under the "H" until it crosses the vertical from 3, and we read our hypothenuse along the radial as 5. (Fig. 23.) If a base of 4 and hypothenuse of 5 are given, and we wish to find the included angle, we proceed as follows: Follow the vertical 4 to where it crosses radial 5 and read the slant to the left on the scale under "H," which gives approximately 53 degrees. Since both the base and hypothenuse are involved, we subtract the 53 degrees from 90 degrees and find our desired angle to be 37 degrees. (Fig. 24.) Thus where the base is involved as either given or desired quantity, use the angle graduations at the bottom and where the hypothenuse is involved either as a given or desired quantity, use the angle graduations at the left and where both the hypothenuse and base are involved, one of which is a given and the other a desired quantity, use the complementary angle of the graduations at the left. By "complementary angle," is meant 90 less the angle shown.

OBLIQUE TRIANGLES.

The simplicity and rapidity of the solution of oblique triangles on this chart has astounded mathematicians. Oblique triangles involve many operations in trigonometry while here practically every oblique triangle dissolves at a glance under the rule that the sides and their opposite angles meet on the same radial.

In the solution of oblique triangles the following cases arise: (1) Given the three sides. (2) Given two sides and the included angle. (3) Given two angles and a side. (4) Given two sides and an angle opposite one of them. In the first two cases the oblique triangle is easily solved by dividing it into right triangles and solving as shown under directions for right triangles. In the last two cases the oblique triangle may be more easily solved directly from the chart without

dividing it into right triangles. Where the oblique triangles are to be solved directly from the chart according to the methods shown below the degree scale to the left under "H" is always used. When two angles and a side are given, the third angle may be found by subtracting the sum of the two given angles from 180 degrees, since the sum of all the angles in a triangle equals 180 degrees. Then when the three angles are known, select the angle opposite the given side, and follow on the chart, the slant line from this angle to where it crosses the vertical line representing the given side; follow the radial line through this point to where it crosses the slant line representing the second known angle, and the vertical through this intersection will give the side opposite the second known angle. Now follow along this same radial line until it crosses the slant line representing the third known angle, and the vertical line through this last intersection gives the side opposite the third known angle, which completes the solution of the triangle. In other words, the intersections of the slants of all the angles and the verticals of their opposite sides fall along the same radial line, that is, the slant of the first angle meets the vertical of the side opposite the first angle on the same radial line on which the slant representing the second angle meets the vertical representing the side opposite this second angle, and on which the slant representing the third angle meets the vertical representing the side opposite this third angle. For example, given an oblique triangle, having one angle of 40 degrees, another angle of 60 degrees and a side of 50 opposite the last given angle. Since we know two angles, we find the third by subtracting the sum of 40 and 60 degrees from 180 degrees, and find the third angle to be 80 degrees. Now follow the 60 degree slant to where it crosses the 50 vertical line, follow the radial through this point, to where it crosses the 40 degree slant, and read the vertical through this last point to obtain the side opposite the 40 degree angle; this side will be found to be approximately 37. Now follow along the same radial

mentioned to where it crosses the 80 degree slant line, and the vertical through this point gives the side opposite the 80 degree angle; this last side will be approximately 57. Thus we have the three sides and the three angles, and the triangle is solved. (Fig. 25.) When two sides and an angle opposite one of them are given, we proceed as follows: Follow the slant of the given angle to where it crosses the vertical of the opposite given side, follow the radial through this point to where it crosses the vertical of the second given side and read the slant throught this point to obtain the angle opposite this second given side. Now we know two sides of the triangle and the angles opposite these two sides. To find the third angle, subtract the sum of the other two angles from 180 degrees, since the sum of all the angles in a triangle equals 180 degrees. Now follow the slant of this third angle just determined to where it meets the same radial line on which the slants of the other two angles intersect the verticals of the sides opposite these other angles and the vertical through the point where the slant of the third angle meets the said radial, gives the side opposite this third angle, thus we have the three angles and the three sides, and the solution of the triangle is complete. For example, given an oblique triangle having one side of 37, another side of 50, and an angle of 60 degrees opposite this last given side. Follow the 60 degree slant line to where it crosses the vertical 50 line, and follow along the radial through this point to where it crosses the vertical 37 line, and the slant line through this last point gives the angle opposite the 37 side; this angle is found to be approximately 40 degrees. Since we know two of the angles, we obtain the third by subtracting the sum of 40 and 60 degrees from 180 degrees, which gives 80 degrees for the third angle. Now follow along this same radial mentioned to where it crosses the slant 80 degree line and read the vertical through this point to obtain the side opposite the 80 degree angle; this third side is found to be approximately 57. (Fig. 26.) In solving oblique triangles

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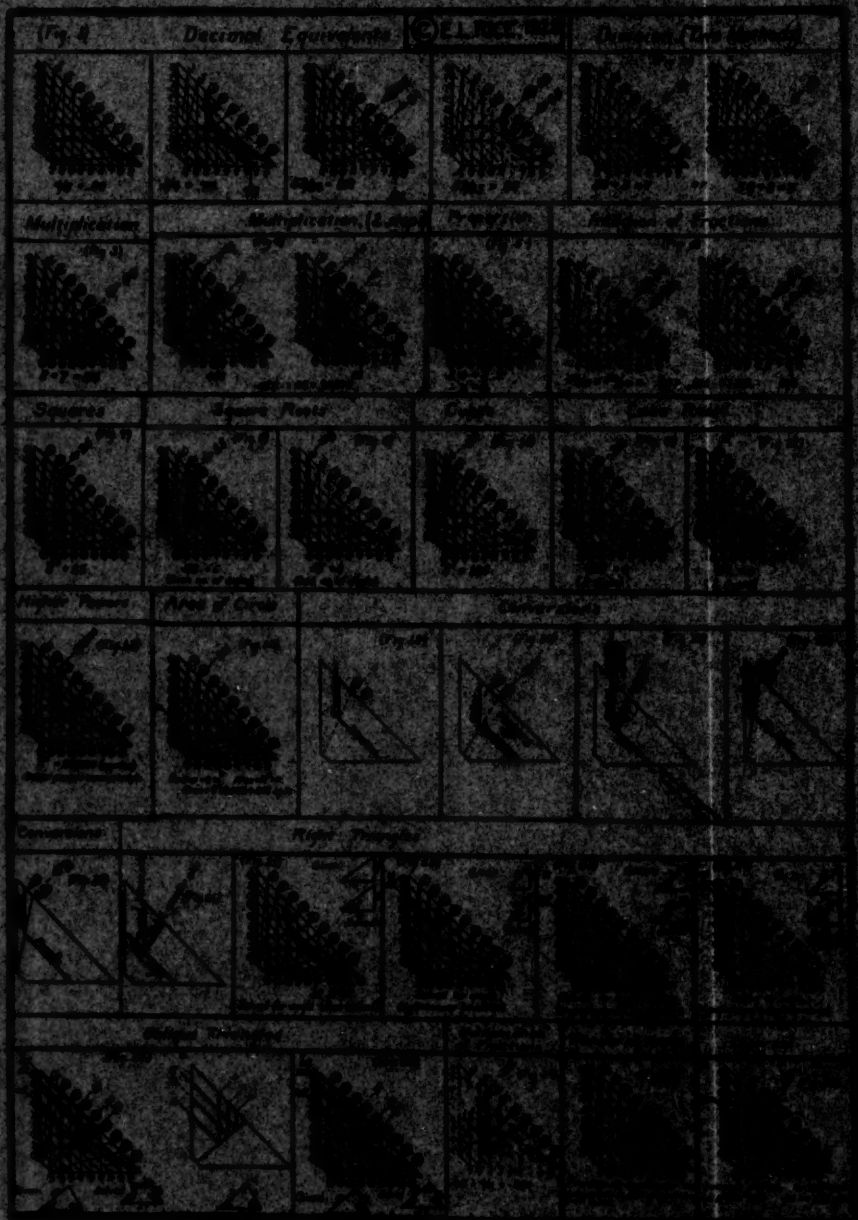
Fig. 4
Decimal Equivalents
Multiplication
Multiplication (Long)
Proportion
Squares
Square Roots
Cubes
Cube Roots
Right Triangle
Area of Circle
Circumference
Right Triangle
Right Triangle

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Division. (Two Methods)
Addition of Fractions
Cubes
Curved Lines

3
4
1
2
SECTION
SECTION

directly from this chart, if one of the angles of the triangle is greater than 90 degrees, the slant line representing this angle will be the supplementary angle and the angle itself may be found by subtracting the angle read on the slant from 180 degrees. By "supplementary angle," is meant 180 degrees less the angle desired. Briefly then, the general rule is that all angles and the verticals of their opposite sides cross on the same radial line.

NOTES.

DIESEL-ENGINED MOTOR CAR FERRY.

The wooden twin-screw motor ferry *Motor Princess*, which Yarrow & Co., Ltd., Victoria, B. C., built for the Canadian Pacific Railway, and the general arrangement drawings of which appeared in "Shipbuilding and Shipping Record," April 19, is now established on its runs between Sydney, Vancouver Island, and Bellingham, Washington.

The Canadian Pacific Railway had this vessel built to meet the demands of the ever-increasing amount of motor traffic between these two terminals, and we understand that the innovation is much appreciated by the considerable number of tourists who visit Vancouver Island, and who are now saved much inconvenience.

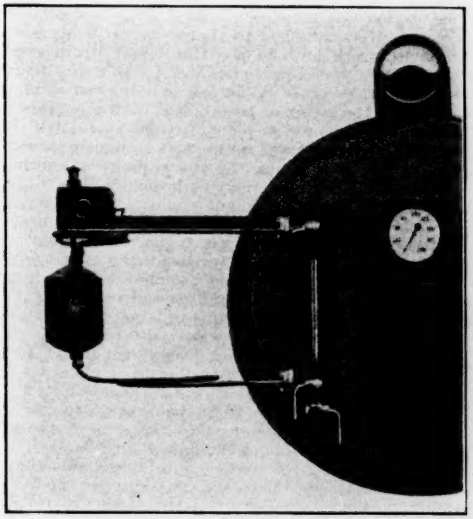
The principal dimensions of the vessel are:—Length, 170 feet; breadth at main deck, 43 feet; depth, 11 feet. Two 600-H. P. McIntosh & Seymour motors gave the vessel a speed of 14½ knots on trial. It is noteworthy that this is the first motor ship of the Canadian Pacific organization. Space is provided on the main and upper decks for the stowage of 45 motor cars. A ramp is fitted to enable the cars to move from one deck to another.

In addition to the special provisions for transporting motor cars the vessel has comfortable spaces for passengers, including lounges, dining saloon and a dance hall.—"Shipbuilding and Shipping Record," October 25, 1923.

A REMOTE LEVEL INDICATOR.

The illustration shows a new remote level indicator of simple and robust construction which has recently been placed upon the market by the Aster Engineering Company (1913), Limited, Wembley. The instrument works on a combined mechanical-electrical system, and consists of two main parts—the actuator and the indicator. The actuator is a steel vessel connected to the steam and water spaces of the boiler by means of flexible coiled lengths of copper tubing attached to levelling valves or the gauge fitting as desired. The steel vessel is furnished with a vertical bronze spindle so arranged that it operates a variable resistance placed in circuit with the indicator. An instrument of the high resistance voltmeter pattern is used for recording the gauge level readings so that the current taken is reduced to the minimum. The operating current may be obtained either from supply mains or from dry cells. Particular attention has been paid to the design of the apparatus so that its working is not interfered with bv the fumes, dust or grit, commonly met with in the boiler-house. It is estimated that a yearly inspection should suffice to maintain the indicator in good working order.

The primary use of this new apparatus, and one for which it was mainly designed, is to show the water level in water-tube boilers where the drum is placed a considerable number of feet above the firing level and a clear view of the gauge glass is often obscured by gratings, handrails and pipe



DISTANT-READING WATER LEVEL INDICATOR.

lines. In the system we have described, a 9-inch dial indicator can be brought down to the firing level and, if necessary, a duplicate instrument installed in the chief engineer's office, where the exact water level in the boiler can be seen at a glance. In a battery of boilers, each fitted with remote level indicators, a selector switch can be fitted to the office instrument so that the water level in any boiler can be made visible at will.

Another use for the apparatus is for showing storage tank levels. For this work a modified design of indicator will be used, and the indicator dial calibrated in hundreds or thousands of gallons, as required.—"The Engineer," October 19, 1923.

INCREASING THE SPEED OF AIR COMPRESSOR REDUCES CAPACITY.

Having read the article, "Increasing the Speed of Air Compressor Reduces Capacity," by J. M. Franklin, in the November 27, 1923, issue, I think he is wrong in assuming that the trouble is caused by the small intake pipe.

In the first place the compressor is apparently rated too high, as a cylinder 16 inches in diameter by 16-inch stroke, with compressor running 135 R.P.M., would have a capacity of approximately 503 instead of 550 cubic feet, as given; and as to the intake pipe's being too small, it seems to me that if the compressor was being worked up to capacity at 135 R.P.M., it should still have delivered the same amount of air at any speed above that.

Now by the same reasoning, when the speed was reduced to 90 R.P.M., the rising air pressure shows that more air went through it at the slower speed, and in my opinion it also shows that the fault lay in either the intake or discharge valves, or possibly both. As the design of the compressor is

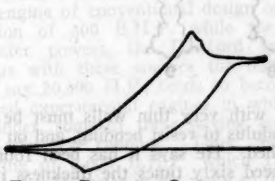


FIG. 1—DIAGRAM OBTAINED AT HIGH SPEED.

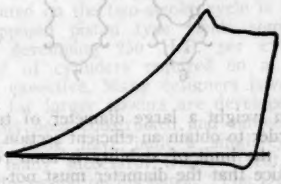


FIG. 2—DIAGRAM OBTAINED AT LOW SPEED.

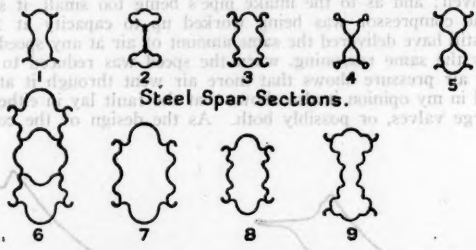
not given, it is difficult to draw any definite conclusions, but I surmise that in all probability the valves were heavy and the springs were too weak to close them promptly at each stroke and consequently allowed a large part of the air to blow back through the valves before they closed. The higher the speed the greater the opening of the valves owing to the higher velocity of the air through them.

I am convinced that had Mr. Franklin used the indicator on the first-stage air cylinder at the high speed, he probably would have obtained a diagram somewhat like Fig. 1, assuming that both intake and admission valves were at fault, while a diagram taken from it at the low, or present speed would be somewhat like Fig. 2. The diagrams shown are free-hand drawings, and no attempt was made to draw them to scale, as they are but to illustrate a point. FRANK AVIS, Clemenceau, Ariz.—"Power," January 1, 1924.

AIRCRAFT DESIGN.

In a paper read before the Manchester Association of Engineers on October 26, on "Aeroplane Design," Mr. Roy Chadwick says that only about thirteen years ago makers of aeroplanes were elated if they turned out a machine which would fly satisfactorily with the pilot and a limited amount of fuel on board, whereas at the present time no fewer than eight different types are being built for military purposes, seven types for naval purposes, and at least four types for commercial work. The military types include the following:—(1) Single-seater scout; (2) two-seater fighter and photographic machine; (3) three-seater reconnaissance machine; (4) single-engined day bomber; (5) single-engined night bomber; (6) twin-engined night bomber; (7) and (8) single and doubled-engined ambulance machines. Naval aircraft includes: Single-engined ship fighters; three-seater fleet reconnaissance ship aircraft; fleet gunnery spotters; single-engined torpedo carriers; single-engined seaplane; single-engined flying boats; and large twin-engined flying boats. Under the heading of commercial aircraft, the author mentions single-engined high-speed passenger and goods machines; twin-engined medium-speed machines for passengers and goods; small "joy-ride" machine; and forest survey and fire patrol aircraft.

On the subject of all-metal aeroplanes, the author says that tubes are unsuitable for main plane spars except for small machines, because for a



Steel Spar Sections.

given weight a large diameter of tube with very thin walls must be used in order to obtain an efficient section modulus to resist bending, and on these lines the limit of stability is soon reached. He says it has been found in practice that the diameter must not exceed sixty times the thickness if the full strength of the material is to be realized. It was, therefore, necessary to evolve special corrugated sections built up from high tensile steel strip from 12 to 28 thousandths of an inch thick. The great difficulties in producing these sections are to avoid premature crinkling of the free edges at a low stress, and to maintain the stability of the webs under heavy end thrust. To overcome the former difficulty the free edges are either curved-in sharply or turned down as far as possible towards the neutral axis, where the bending stresses are a minimum.

The following methods have been adopted for maintaining the stability of the webs:—(1) Reduction of depth to a minimum. Section Nos. 2, 7 and 8. Section 8 has same web as No. 3, .015 inch thick, and although of greater depth is a more efficient spar. (2) Riveting two webs together along center line as in Nos. 1, 4 and 5. This is the principle of two drunken men holding each other up. (3) Connecting together at intervals. This is done in the case of sections 1 and 9 by small distance tubes and when necessary with section No. 7, by means of bulkhead diaphrams. (4) Introduction of longitudinal diaphragms, as in No. 6. This appears to be the most suitable method for large spars.

A great amount of research work has now been carried out on the development of corrugated steel spars and wings are now produced in steel as light and strong as the wooden ones. Mr. Chadwick says it seems probable that before long all machines required to operate under varying climatic conditions will be built entirely of steel.

Prior to the meeting at which the above-mentioned paper was read, the members of the Society had an opportunity of inspecting the works of Crossley Motors, Limited, Openshaw, and A. V. Roe and Co., Limited, Newton Heath. At the former works the members were met by Sir William Letts. They were enabled to view the whole of the processes involved in the manufacture of motor cars and aeroplanes, and were favorably impressed by many of the machine tools in use at the former works. Some of the most original tools for special purposes have been built in the works, such, for instance, as a multiple drilling machine for gear boxes and engine cylinder blocks, worm gear cutting machines, &c. One of the machines seen is capable of drilling sixty-five holes at one setting with the aid of a simple jig. The employment of jigs on boring and milling machines was noted, as well as the thoroughness of the methods employed in the balancing of the moving parts of the engines, such as the connecting-rods and crank shafts. At the aeroplane works the processes employed in building flying machines of all sizes and types up to the latest bombing machines weighing 6 tons, fitted with 675 horsepower engines, were inspected.—"The Engineer," November 9, 1923.

HIGH-POWERED HEAVY OIL ENGINES.

While the heavy oil engine as at present designed is capable of yielding units of sufficient power for the propulsion of cargo vessels of ordinary dimensions—and these after all form the bulk of our merchant tonnage—the question is sometimes raised as to whether these engines could be made suitable for the propulsion of large high-speed liners. As at present designed, the maximum power which can be developed per cylinder from an engine of conventional design operated on the two-stroke cycle is in the region of 500 B.H.P. while the opposed piston type yields somewhat greater powers, the Doxford type developing 750 H.P. per cylinder. Thus with these engines the number of cylinders required on a vessel of, say 20,000 H.P., tends to become excessive. Many designers have produced experimental engines in which far larger powers are developed per cylinder, some of these having actually been constructed and subjected to experimental running. Thus, Sulzer Bros. have built a single-cylinder engine of 2,000 B.H.P. which ran many successful trials. Lieut.-Com. L. J. Le Mesurier in his reply to the discussion on his paper, "The Development of the Sulzer Engine," mentioned that as a result of the experience gained with that engine a far better proposition for a unit of 2,000 B. H. P. could now be put forward, and while he considered it unprofitable to speculate on the engine of the future, he ventured to assert that if there was a demand for a merchant vessel of even 60,000 B.H.P., it could be taken as quite certain that means could be provided for driving such a ship with Diesel engines. This, at least, indicates that firms are not prepared to consider that the Diesel engine has reached the end of its tether.—"Shipbuilding and Shipping Record," October 18, 1923.

PARSONS TURBINE COMPANY PROPOSES GEARED OIL ENGINE DRIVE.

The reduction-geared oil-engine system as developed in America evidently has impressed British engineers, as the Parsons Marine Steam Turbine Co., Ltd., Newcastle, has proposed to use a number of high-speed, enclosed four-cycle oil-engines with geared reduction to the propeller shaft. In

the case of one pair of engines, they are arranged alongside each other; in the case of two pairs, one is situated above the other, the two upper units being pitched somewhat farther apart than the lower two units. The drive from each engine is taken to the propeller through the medium of an elastic frictional coupling, built into the fly-wheel friction clutch and single reduction gearing. This makes it, of course, possible for both propeller and oil engines to be run at widely different speeds. An inspection of the "4-unit" model makes it apparent that the accessibility of the two lower units is inferior to the arrangement indicated by the "2-unit" model. In both cases, of course, any of the units can be cut-out, any possible defect remedied, and the unit connected up again without stopping the vessel.

A novel departure is the proposed utilization of the exhaust gases. The cylinder jackets and an oil-fired boiler form a closed circuit, the water from boiler to jackets passing through a regenerator (vertical type), heated by the exhaust gases. The system is designed to handle steam pressures up to 250 pounds per square inch, the steam being used for auxiliary purposes in the engine-room. It is claimed that sufficient steam is generated to drive the whole of the engine-room auxiliaries; hence the saving in fuel is considerable, despite the fact of using a less efficient system as compared with oil-engine generators and electric-driven auxiliaries.

Steam is generated in the oil-fired boiler, circulating commences and warms up the cylinder jackets ready for starting. In this respect the method is analogous to that employed in the Doxford engine. It is also possible to use a lower compression, because the higher cylinder temperature ensures a positive start and also makes up for any loss of thermal efficiency due to lower compression and higher speed of revolutions.

For starting the engine, air is used in the conventional way or steam. In the latter case the starting and maneuvering gear is identical to that employed with air, and steam is admitted to the top of the cylinder by some ordinary type of starting valve. Owing to the pre-heating of the cylinders the engine is always certain to get away very quickly and hence the steam consumption is very low.

One proposal includes four trunk type, six-cylinder engines, aggregating 1,200 B.H.P., geared down from 450 R.P.M. to 75 R.P.M., at the propeller. The total weight of machinery, including gearing and propeller gear is 225 tons, and the length of machinery space 26 feet 9 inches plus 5 feet 6 inches recess. The other and probably more attractive, system includes two six-cylinder crosshead type engines, also of 1,200 B.H.P. total, with engines at 300 R.P.M. and propeller at 75 R.P.M. Complete weight of machinery in this case is 266 tons, to be accommodated in 32 feet length of engine room, plus 5 feet 6 inches recess. Whilst the extensive use of steam may in certain quarters be taken as a retrograde step, the Parsons system embodies a number of points that are attractive from the commercial and practical point. This development in England and its application to marine practice will be watched with considerable interest.—"Motorship," December, 1923.

POINTERS ON THE MAINTENANCE OF COMMUTATORS.

By A. R. Knapp.

When word comes to the man in charge of the electrical equipment of a plant that a motor is not acting properly, his thoughts will in all probability immediately concentrate on one particular part of that machine. That part will be the commutator. A large percentage of every-day motor trouble can be traced directly to that important member. It may properly be termed the business end of a motor, and it is good business to see that it gets the best possible care and attention.

Most text-books on electrical machinery usually give a lengthy list of probable causes of motor troubles. It is the purpose of this article to give a few hints on the care of commutators from the viewpoint of the man directly charged with the responsibility of continuous operation. All the cases and remedies mentioned herein have been encountered in actual practice, and it is the earnest hope of the writer that some of them may be of benefit to the craft.

To ensure that smooth, glossy, chocolate color to commutators so much sought by operators, several simple rules must be formulated and strictly adhered to. Rule one is that a regular daily inspection be made of all motors. It is only in this way that one can keep in touch with each motor's peculiarities, and promptly check any irregularity that may arise from day to day.

Clean Motors with Compressed Air.—It should be the rule to clean motors periodically. Compressed air is best for this purpose. The armature core should be thoroughly cleaned, especially the ventilating air ducts through the core, which are put there for the express purpose of creating a current of air through the core, thereby carrying away much of the heat generated in the armature windings. Yet it is no uncommon occurrence to find these ducts completely clogged with solid matter.

With motors operating in dusty places, particles of dust and the products of manufacture will often collect on the brush-holders to a considerable extent. Should there be sparking at brushes, this foreign matter often catches fire. This is not only dangerous to the motor, but the fire hazard to the building is greatly increased, due to flying sparks.

Rule two is that all commutators be wiped clean with a soft cloth each day. This is a very simple operation, but a very important one. Ninety per cent of motor troubles originate from neglected commutators that are allowed to get gummy with oil leakage from the motor bearing. Together with carbon and copper dust it will form a gummy smear on the commutator surface, the brushes become saturated with it, and from that point it is but a short step to costly repairs.

This mixture of carbon and oil is a conductor of electricity, and it will eventually soak into the mica segments, resulting finally in leakage of current from bar to bar. A small arc will be set up between the two bars. This arc may burn itself free, but in the majority of cases it will increase in intensity, resulting in a burn-out between bars. Frequently good armature coils are ruined from the fusing together of two bars.

A clean commutator and brushes, kept dry and free from oil, will very rarely show signs of burning between bars. Eliminate this hazard, and the operator has taken a great step towards reducing to a minimum costly motor shut-downs and repairs. Therefore, make it a positive rule to keep every commutator on the job perfectly dry and clean.

Sandpaper has no logical place in the operation of commutators, and the farther away it is kept from the smooth surface of a mass of copper and mica, so much the better for motor harmony. The same may be said of commutator compounds—that black, gummy stuff so often passed on to the man in charge as a cure-all for motor troubles. These compounds are largely a lubricant, and if lubrication is needed use paraffin or a small amount of machine oil, applied with a cloth.

Frequently troubles arise due to other causes than the one mentioned above. Glowing of the brushes at the surface of the commutator sometimes occurs. This can be due to a number of causes, such as incorrect brush position, brushes not properly spaced, high mica, and brushes covering too many bars. One serious case of glowing was corrected by substituting brushes one-eighth inch narrower than those in use.

Sparking due to burnt spots on the commutator is a very common occurrence. These spots may be equally spaced, or they may occur at irregular

intervals. In either case the cause of this particular trouble is often hard to locate. In one instance it was found to be caused by a loose coil connection to the commutator. The trouble was further aggravated by the fact that this loose connection was what is known as a "flying open." Violent sparking would occur when the motor was in operation, then suddenly the sparking would cease. This would go on intermittently during the day. The trouble was finally traced to the loose armature lead, which would make and break contact, probably due to variations in the motor speed.

Effects of Open Circuits.—Effects of a dead open circuit are very apparent. There is a violent, snapping, bluish-green spark at each brush edge as the bar of the open-circuited coil passes beneath each set of brushes. The spark seems to reach out from the brush edge, and attempts to follow around the commutator. The bars to which this coil is connected will be found to be burned and pitted, and the mica segments between eaten out to a considerable depth.

MAINTENANCE OF COMMUTATORS.

In another case, black spots were found to be caused by one set of brush-holders moving out of proper alignment. A strip of heavy paper was drawn about the commutator and the brush positions marked. The paper was then withdrawn and the marks measured. They were found to be unequally divided. The strip was then marked off in four equal divisions and the brushes set to these marks.

An overloaded motor will often produce burnt spots on a commutator. A frequent cause of burning is due to high mica. All or nearly all the bars will be found in this condition, leaving the mica segments protruding slightly above the surface. Continual sparking and heating results, due to poor brush contact. If this condition persists for any length of time, the commutator will become hot enough to melt the solder from the coil connections. A shut-down and a repair is then a certainty.

High Mica.—In some cases, high mica is the result of several conditions in no wise chargeable to the operator. One of these is that the mica is of too hard a grade. The copper wears faster than the mica, leaving it protruding above the surface of the copper. Another is that the copper bars are considerably softer than the mica. This condition will produce the same result. Segment copper is usually drop-forged or hard-drawn. With hard-drawn bars the copper and mica will usually wear evenly. It is with cast-copper bars, formerly largely used, that most of the high-mica troubles arise.

Most of the men in charge of electrical equipment will work out their own salvation when troubles arise. Some will be content to turn down the commutator occasionally, and let it go at that. This method will give a smooth-running machine for a short time, but it is costly in labor and greatly shortens the life of the commutator. Some of them will be guided by the opinion of a smooth-tongued brush salesman. This pest will usually advise their "special abrasive brush made expressly for such conditions."

He goes on to state that the abrasive qualities of the brush will grind down the high mica, and your troubles will end as if by magic. He fails to state, however, that the brush will also grind down the copper and very decidedly shorten the life of the commutator.

A man that is really on his job will seek until he has located the cause of the trouble. Once the cause is found and remedied, sparking will cease permanently.

If it is certain that high mica results from the natural condition of the copper or mica, then undercutting is about the only permanent relief. To do a good job of undercutting requires some knowledge of operating conditions, and quite a bit of patience. Many different tools and methods have been devised to do the work. The average manufacturing plant would not be justified in purchasing one of the elaborate electrically-driven saw outfits made for this purpose. Occasionally the work can be done in a milling machine. All things considered, the hand method, while taking longer to accomplish the same result, nevertheless often produces a more satisfactory job. A 6-inch slim taper file is the only tool necessary. Break off about ½ inch of the file tip and grind square. Hold the file at a slight angle to the commutator surface; about as shown in the accompanying sketch.

Start the file at the end of the mica segment and work back towards the armature core, keeping in the center of the mica. The square end of the file will act as a sort of plough. Remove the mica to a depth of about 1/32 inch. The shallower the slots, the easier to keep clean and free from accumulations of carbon dust and grit. Be sure that the entire width of the mica is removed. A thin sliver left flush with the surface of the copper will often defeat the purpose of undercutting. All sharp edges should be removed from the copper bars.

One precaution to be taken with undercut commutators is that oil should not be permitted to work on to the commutator. Oil and carbon dust will clog the slots and cause endless trouble.

A hard, non-abrasive carbon brush will give good results when undercutting is resorted to. Brush tension can also be reduced considerably. Usually 1½ pounds per square inch of cross-section is sufficient.

Practically all repairs to commutators can be made in the average industrial plant repair shop.—"Power Plant Engineering," "Mechanical World."

THE NAVY'S CONTRIBUTION TO INDUSTRY.

The present agitation in favor of the complete abolition of armaments and, therefore, of our splendid Navy, is unthinking, uninformed, and generally springs out of an abysmal ignorance of the subject. To be consistent, the advocates of complete disarmament should call also for the abolition of those police forces which enable city dwellers to work and sleep in security.

In a recent issue, we touched upon this subject, and laid special emphasis on the value of the Navy as a training school for our young men in habits of orderliness and discipline, and in respect for constitutional authority. We now draw attention to the fact, so generally overlooked or ignored, that the great merchant fleet which fetches and carries the products of industry is equally indebted to the Navy for the great technical improvements which have helped to raise it to its present standard of speed, comfort, reliability and high operating economy.

Take the fundamental question of ship propulsion. Less than 25 years ago the cumbersome reciprocating engine was in exclusive possession of the field, both as to freight and passenger ships; and it is largely to the ceaseless initiative and support of naval engineers, both here and abroad, that

the world owes those successive improvements which have given to us, first, the direct connected-turbine, then the geared-turbine, and lately the steam-electric drive, which last has proved itself so satisfactory to our Navy that the latest battleships are equipped exclusively with this system. To the navies of the world, also, we are indebted for much experimental work in the development of the Diesel marine engine, which in economy of weight, space and consumption stands so far in the lead as to be in a class by itself.

But, although its work in developing improved means of propulsion is its greatest contribution, we must not forget that there are hundreds of other directions in which this great "laboratory of experimentation," as the Navy has justly been termed, has made generous contributions to industry. The electrically operated winches, pumps, ventilating fans, and various other auxiliaries which are now being introduced aboard merchant vessels, have been in use for over fifteen years in our Navy. Furthermore, the Navy was a pioneer in the use of super-heated steam; and the Merchant Marine is indebted to it for research work in developing alloys of various kinds for condenser tubes and other purposes; for its elaborate investigations of lubricating and fuel oils; and for its development on a large scale of electrical welding methods. The Navy's model basin at Washington, moreover, is responsible for improved models, not only of merchant ships but many of the notable steam and sailing yachts of the country. In this connection, it may be stated that the lines of not a few of the American cup defending yachts received their final determination as the result of trials in the Navy towing tank. When we come to navigation, we find that the Navy has rendered invaluable assistance. To its Hydrographic Bureau, we are indebted for extensive marine surveys, and for the superb charts, issued regularly by the Hydrographic Bureau. The ice patrol safeguards the passage of our great liners by locating and distributing by radio the position and course of those terrors of the seas, the icebergs. Many a good ship has been saved from disaster by the "radio compass" system, a Navy development by which ships as they approach the coast can obtain their exact locations, even when they are shut in by dense fogs and blinding snow storms. When a ship enters the harbor channel, she can maintain herself accurately within her narrow limits, keeping in electrical touch with a pilot cable laid on the bottom through the center of the channel. Only recently we illustrated in this journal the new Navy system of sounding by sound, the practical operation of which was recently proved when a Navy ship charted the ocean floor from America to Europe in a fraction of the time which would be necessary by the old method.

Nor must we forget that the Navy gave to the steel industry in America the greatest single impetus which it has ever received. Thirty years ago, when we began to build our first steel ships, we possessed no mills that could fabricate the heavy forgings needed for armor plate and guns. Such things could be obtained only abroad; but the Navy arranged with American manufacturers to install the necessary plant for this heavy work; and it was this far-sighted policy which started our heavy steel trade on an upward course, which, within a few years, had made us the premier steel manufacturing country in the world. So far from its being an economic waste, the Navy is at once the police force of the nation, a training school for its youth, a great laboratory for the development of new industrial processes, and one of the greatest exponents of the true "live and let live" patriotism.—"Scientific American," November, 1923.

BRITISH NAVY AIRCRAFT CARRIERS.

A great development has taken place in the use of aircraft for fleet purposes since the establishment of the Royal Naval Air Service, a few years before the war. All nations have recognized this, and their navies now include vessels specially arranged for the carriage and operation of aircraft. It was early perceived that a new factor had come into existence whose effect upon the tactical handling of fleets was likely to be of a revolutionary character. By skilful use of a smoke screen it had been possible hitherto for an enemy to break off an action and escape, but the participation of aircraft in a naval action rendered this maneuver no longer of service. The use of aircraft enables all the movements of an enemy to be immediately observed and allowed for, and therefore simplifies many of the problems of gunnery control; while aerial reconnaissance will give the admiral in command exact knowledge of the composition and disposition of the enemy's forces long before actual contact between the fleets has been established.

The limitations of the usefulness of aircraft when flown from a shore station are obvious, and so are the difficulties of handling seaplanes from ordinary ships by means of derricks, and of flying these machines from the water in an average seaway. From this has resulted the inception of the aircraft carrier, a vessel specially designed to carry airplanes, and in its further development, to enable them to be flown off and landed on the deck.

The importance of aircraft carriers has been steadily increasing, and they have been honored by special mention in the Washington Naval Treaty in which they and capital ships are the only types of warships which are defined and limited. In Part IV of that Treaty an aircraft carrier is defined as a ship having a displacement (ex fuel) of above 10,000 tons, designed for the specific and exclusive purpose of carrying aircraft. The maximum displacement of any aircraft-carrying ship is limited to 27,000 tons, except that for provision of conversion of vessels built as capital ships 33,000 tons each is allowed in the case of two ships. The armament of aircraft carriers, as for light cruisers, is limited to guns of a caliber not exceeding 8 inches. The combined tonnage of all aircraft carriers possessed by the British Empire must not exceed 135,000. It is also provided that all aircraft carriers building, or in existence on November 12, 1921, can be replaced without regard to age within the total tonnage limit prescribed. This would enable any, or all, of the existing carriers in the British Navy to be scrapped, if desired. Although it is most improbable that full advantage will be taken of this proviso, the generous allowance of total tonnage opens up a fair prospect of naval shipbuilding in this direction.

The earliest aircraft carriers in the British Navy consisted mainly of cross-Channel steamers which were fitted to carry seaplanes; no facilities were provided for the flying off or landing of aeroplanes. Among these ships were the *Empress, Engadine, Riviera, Ark Royal, Ben-My-Chree, Vindex, and Manxman.* Experiments carried out on these vessels, as well as on the *Campania* and *Furious,* revealed the possibilities of flying off and landing, and enabled the usefulness of aircraft carriers to be very sensibly augmented. The carriers now on service or completing are the *Ark Royal* and *Pegasus*—small ships of the older type, and the *Argus, Eagle, Hermes* and *Furious* which are well-equipped up-to-date ships. All these vessels except the *Hermes* have been converted for their present service. The *Hermes* was specifically designed for the purpose.

Of these vessels the *Argus* was described in "Engineering" on March 28 and April 4, 1919. She was launched in July, 1917, and is the only modern type carrier yet actually on service. H.M.S. *Furious,* originally a cruiser, was completed in July, 1917, and is now undergoing a further reconstruction. The *Eagle* and *Hermes* have each just completed their trials. Particulars of these ships, together with the older carriers are given in the table below:—

Ship.	*Length.*	*Navy List Displacement.*	*Designed Horse-Power.*	*Approximate Speed.*
				knots.
Ark Royal	366	7,080	3,000	11
Pegasus	332	3,070	9,500	20¼
Argus	565	14,450	20,000	20.2
Hermes	598	10,950	40,000	26
Eagle	667	22,790	55,000	25
Furious (before present reconstruction)	786	19,100	90,000	31

For comparison, it may be stated that the only other completed aircraft carriers in existence are the U.S.S. *Langley* (described and illustrated in our issue of September 14 last), which has a length of 524 feet, a displacement of 19,360 tons and a speed of 14 knots, and the *Hosho*, of the Imperial Japanese Navy, which was completed in 1922, and has a displacement of 9,500 tons.

The *Hermes* was designed by the Director of Naval Construction and built at the Naval Yard at Walker-on-Tyne of Messrs. Armstrong, having been laid down in January, 1918, and launched in September, 1919. To the particulars given in the table above may be added: Breadth, 70 feet below, 90 feet at flight deck; draught, 18 feet 9 inches; oil fuel stowage, 2,000 tons. She was considerably delayed in her early stages by important alterations and improvements in design which were made as the result of further experience in mid-1918; and some delay of necessity arose when she was transferred to Devonport Dockyard to complete. As already stated, she is the only aircraft carrier designed and built as such, and has thus escaped the disadvantages inseparable from a reconstructed ship; but the length of time occupied by building and completing her, although unavoidable, is rather apt to be prejudicial to a ship's final efficiency, and it is therefore a matter of congratulation to all concerned that she has undergone a most extensive series of trials with—as we understand—complete success.

Very few particulars of the *Hermes* have been published; but it is known that she is provided with anti-torpedo blisters and is propelled by twin screw geared Parsons turbines. Her armament consists of six 5.5-inch and some anti-aircraft guns. Like the *Eagle* she is provided with an "island" unsymmetrically placed on the starboard side of the flight deck, which contains the funnels, mast, fire control and navigating positions. Apart from these rather scanty particulars, little information is available; but it may be of interest to refer to some features which are common to all modern aircraft carriers.—"Engineering," November 21, 1923.

BREAKING UP LARGE MASSES OF STEEL.

A new method of breaking up large masses of steel—such, for example, a ladle "set"—so as to produce pieces small enough to be fed into melting furnaces, has recently been brought to our notice. The method, which is being successfully pursued by Messrs. Thompson and Co., of Wigan, consists in boring a number of holes in the metal, charging them with gelignite, and then exploding the charges after the metal has been lowered into a specially prepared pit.

The means adopted for boring the holes is interesting. A long length of ¼ inch outside diameter iron pipe is connected by flexible tubing to a cylinder containing oxygen gas under pressure. The free end of the pipe is inserted into an ordinary fire bucket and, when the tip has reached a

Boring Holes in a Ladle "Set."

A Broken-up Mass of Metal.

red heat, the oxygen is turned on slowly. The result is that the metal of the pipe is ignited and continues to burn with the production of a very high temperature. The flaming end of the pipe is then applied to the surface of the metal in which it is desired to bore holes, and we understand that it is possible to "push" a hole about 1 inch in diameter and some 3 feet 6 inches deep in solid steel with the consumption of some 14 feet of the ¼ inch pipe. The correct gas pressure is regulated by means of a hand valve on the oxygen cylinder, and we are informed that the pressure employed is sufficient to keep the hole clear of molten metal.

One of the accompanying engravings shows the process of boring holes in a ladle "set" weighing 45 tons 13 hundred-weight, while the other is a view looking down into a blasting pit after an explosion, and shows the comparatively small pieces into which the mass of metal has been split up.—"The Engineer," November 16, 1923.

USEFUL STEAM APPLIANCES OF ROYLES LTD.

The firm of Royles Ltd., engineers, Irlam, near Manchester, are the makers and patentees of many ingenious and economical steam appliances and in these days of rigid economy it will not be out of place to describe one or two of their well-known productions.

ROW'S PATENT INDENTED TUBE.

The Row tube, which is here illustrated and which forms the basis of many of their specialties, is worthy of more than passing consideration. It is made by taking a plain round tube—usually of solid drawn copper—and indenting it in a suitable machine in a regular manner, the indentations preferably intersecting each other at right angles, so that a fluid passing through the tube is thoroughly broken up and diverted into contact with a large amount of impinging surface.

It is found that a tube so indented has very remarkable heat-transmitting properties much in excess of the plain round tube from which it is formed. The exact reason for this may be difficult to state, but no doubt it has to do with the laws of heat transmission through surfaces or plates, in which one well-known fact is that an accumulation of condensed water in the form of particles or globules on the tube surface seriously interferes with the transmission. The break up of the central core of the tube increases the velocity of the steam through it, so tending to sweep off the particles and keep the steam in active contact with the copper. Similarly the break up of the exterior of the tube produces a series of impinging surfaces which cause a rapid exchange of fluid on the outside, and enables full advantage to be taken of the other well-known law on this subject that the transmission is greatly increased if the fluid being heated is kept in rapid movement over the heating surface.

Whatever may be the theory by which it is explained, it is found that a tube indented in this manner has a heat-transmitting property remarkably in excess of exactly the same amount of plain round tube surface, as the following experiment clearly shows.

Two pieces of solid-drawn copper tube 1½ inches internal diameter, both 2 feet 6 inches long (exactly one square foot of surface), are prepared by brazing on the ends suitable caps tapped for connecting pipes. One tube is left plain; the other is indented under the "Row" patent (shortening about ten per cent in the operation), but both obviously still having the same amount of surface. Each tube is placed in a tank of water, the outlet of the tube passing through the bottom of the tank and being left free and open to the atmosphere. Each of the tubes is served with steam

INDENTED TUBE—"ROW'S" PATENT.

FEED HEATER WITH INDENTED TUBES.

A. Feed-water Inlet. B. Feed-water Outlet.
C. Steam Inlet Valve. D. Tube Box.
E. Battery of Rows Patent Indented Tubes.
F. Condensation Box. G. Condensation Outlet.
H. Funnel for Soda Solution. I. Inspection Door.
KK. Brackets.

at the top end at atmospheric pressure or thereabouts, care being taken that steam issues at the bottom equally in both cases, so that each tube has as much steam as it will take up but without pressure. The water in the vessel is agitated by paddles to get an average temperature throughout and the following table shows the comparative efficiency of the two tubes:

TABLE.

Description of Test.	*Plain Tube.*	*Indented Tube.*
Temperature of steam to tubes.....	212 degrees F.	212 degrees F.
Temperature of water at start.....	48 degrees F.	48 degrees F.
Quantity of water in casing.....	21 gallons	21 gallons
Quantity of surface in tube.....	1 square foot	1 square foot
Time to heat to 180 degrees F. at thermometer	106 minutes	58 minutes

The superiority of the "Row" surface is evident, being practically two to one over the plain tube, and it will be at once apparent why such apparatus is more compact and relatively more efficient than is possible with plain-tube surface.

Another very important property of the "Row" tube, arising directly out of its formation, is that the tube is elastic in the direction of its length, and can, therefore, be secured between tube plates without fear of fracture or leakage. This is a most important and valuable property, and has a bearing upon the durability of the apparatus. The elasticity of the tube is considerable. The efficiency of the tube is relatively the same whether the steam be inside and the water outside, or *vice versa;* but, in the case of waters containing salts of lime and other solids, the water should obviously be outside, and, in the important subject of feed-water heaters, calorifiers, etc., special attention has been given to this.

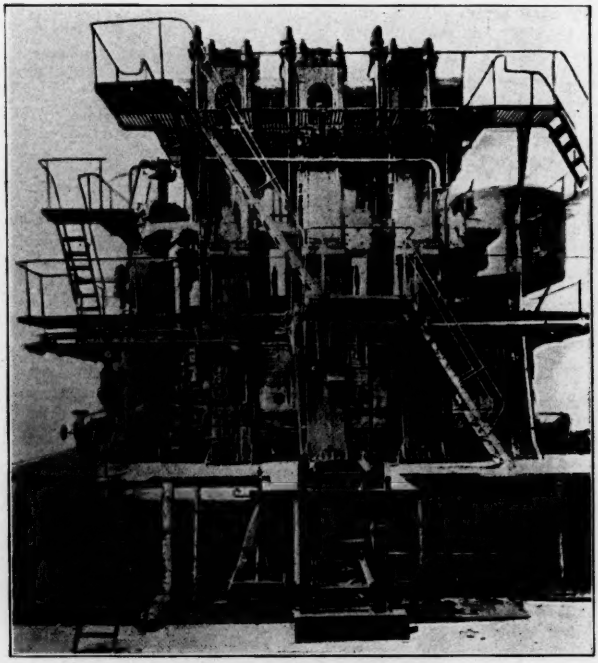
It is further found that the patent tube casts scale more readily than plain tube surface, which is of importance when the tube is used in appliances using water containing salts of lime, etc., or in the case of evaporators using salt water. In both these cases a tube that will to some extent clear itself naturally is a desideratum.

The feed-water heater, here shown, is devised to utilize the waste heat from exhaust steam and turn it to account in heating up boiler feed water. The economy arising from this is obvious, and varies considerably with the circumstances of each case, but it is well established that the difference in fuel consumption between feeding a boiler with water at 200 degrees F., instead of cold water, is 13 per cent, and very often much higher. The boiler, also, is saved much wear and tear from irregular expansion and contraction.

In this type of heater the feed water is kept on the outside of the tubes, and the steam, or such portion of it as is necessary is sent through the tubes, and should always be selected for dealing with feed waters which contain salts of lime or other solids in solution or are highly charged with other impurities.

The construction of the heater will be readily understood from the annexed section.

The feed water enters by the inlet A into the body of the heater and passes through and around the "Row" tubes E on its way to the outlet B. The heating steam by the steam inlet valve C by which it is admitted to the inside of the tubes and after giving up its heat to the feed water is drained by the cock G from the condensation box F. The heater is fitted with an



NEW 2,000 BRAKE HORSEPOWER, DOUBLE ACTING, TWO CYCLE NORTH BRITISH DIESEL ENGINE.

inspection door I and a cock H for furnishing a supply of soda for softening purposes, and with brackets KK for suspension purposes. The shell, distribution box, and base are made of the best close-grained cast iron and the tubes of solid-drawn copper.—"The Steamship and other Power Vessels," November, 1923.

NORTH BRITISH 2,000 HORSEPOWER DOUBLE-ACTING DIESEL ENGINE.

By Our Special London Correspondent.

A certain amount of preliminary information has already been published concerning the new type of double-acting two-cycle engine which the North British Diesel Engine Works has developed. The 2,000 brake horsepower two-cycle set which this firm is constructing for installation in a 5,000-ton cargo ship is now completed, and some details of the results achieved are of special importance in view of the fact that a great saving in weight and space has been effected by the adoption of this principle of operation.

As will be seen from the illustration, the engine has three cylinders, the dimensions being 24½ inches bore and 44 inches stroke; the rated power given above is developed at 100 revolutions per minute. The length of this engine over-all is only 30 feet, including the crankshaft driven scavenging pump and the air compressor. The height is approximately the same and the width over the bedplate is scarcely more than 10 feet. Perhaps the most important fact of all, however, is that the weight is only about 200 tons, whereas it is considered that an average four-cycle single-acting engine would weigh about 360 tons to develop equal power at the same speed.

On the left can be seen the control gear which is all hand-operated, the fuel pumps being driven by a mechanism on the sliding cylinder itself. The camshaft is thus eliminated with the idea of simplifying the design. Exactly the same principle of operation has been employed as in the experimental engine which was built before constructing this large set. The cylinder has a sliding motion and, in its movement in relation to the piston, uncovers the exhaust and scavenging ports at the correct times. The cylinder slides over the top and bottom covers, a distance of some 12 or 15 inches, and the gudgeon pin is brought out through slots in the cylinder, allowing the drive to be taken on to the crankshaft through a forked connecting rod. The cylinders themselves are driven from the main crosshead pins and although the employment of sliding cylinders may seem to be somewhat surprising, it is claimed that no difficulties are likely to be encountered from this construction.

It is not to be expected that the fuel consumption of an engine of this class will be equal to that of a four-cycle single-acting motor. It was found on the preliminary trials that the figure attained was about 0.45 pound per brake horsepower hour, this being some 12 or 13 per cent higher than with the modern Burmeister & Wain four-cycle single-acting type. It is possible, however, that improved results will be achieved with further experiments, and in any case the saving in weight and space—and presumably cost—is so important as to give the engine a wide field of application, should it prove thoroughly reliable in service.—"Marine Engineering and Shipping Age," December, 1923.

STATIC AND DYNAMIC BALANCING.

The Vibrator Specialty Company of Philadelphia, cooperated with the Akimoff Propeller Company in demonstrating the combination static and dynamic balancing machine at the exposition. A 24-inch diameter bronze propeller was mounted and the method of operation explained. The machine can

be instantly set for static or dynamic balancing and gives, as the company states, results of greatest accuracy. It gives the plane and the amount of correction to be applied to the body to make it operate smoothly, *i.e.*, in short vibrations. Machines of this type find wide application in industrial plants to accurately balance crankshafts, fly-wheels, propellers, armatures, pulleys, etc.

Larger machines for balancing turbines and rotating fields, weighing up to 15,000 pounds are manufactured by the Vibration Specialty Company.

Not long ago the Vibration Specialty Company balanced five turbo-generators of the S. S. *Leviathan*. The portability of the machines made it possible to bring them into the turbo-generator compartment of the ship. Results were secured which exceeded all expectations.

The Akimoff Propeller Company also exhibited models of propellers built entirely along the lines of the circulation theory. These propellers look very much like any other but are developed on a radically different basis tending as it is claimed to unusually high efficiency.—"Marine Engineering and Shipping Age," December, 1923.

BETHLEHEM CORPORATION PRODUCING PLANT MILLS DIRECTION INDICATOR.

The Bethlehem Shipbuilding Corporation, Ltd., demonstrated the Plant Mills direction indicator and engineer's alarm at its booth this year. The rights for the manufacture of this device have been taken up by the Bethlehem people, who are manufacturing it at present at the Union Plant, Alameda, Calif.

This device is used as an aid and safeguard in maneuvering vessels at close quarters. The direction indicator keeps the navigator wherever he is on the bridge constantly informed as to the handling of the engines and the engineer's alarm provides a prompt and efficient means whereby the engineer is instantly and automatically warned should he fail to operate the engines in accordance with directions from the bridge.

The bridge indicator, visible from any part of the bridge, shows the speed and direction of the engines; a white light flashes from three upper lenses for every revolution ahead and a red light flashes from three lower lenses for every revolution astern.

By means of flashing red lights and alarm bell in the engine room, the engineer is warned of an error in answering the bridge signals, the alarm operating until the error is rectified. Parallel wiring is used throughout the system.—"Marine Engineering and Shipping Age," December, 1923.

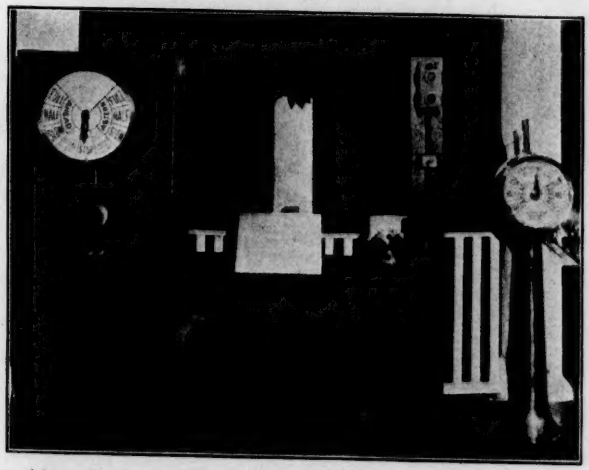
ARC WELDER FOR SHIP WORK AND NEW GALLEY RANGE.

The Todd Shipyards Corporation in its exhibit showed the Todd twin-pole arc welder which has been developed especially for use on board ship where it comes into service in the repair of leaky seams, fire cracks, leaky pipe joints, worn machinery parts, loose or broken rivets and other essential repairs that can be made by welding.

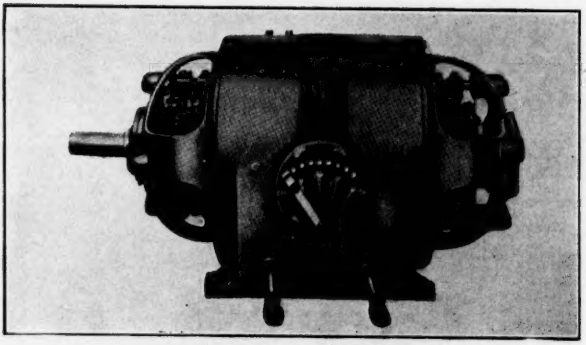
The Todd welder has been designed for quick work and its small size and weight, it is said, particularly adapt it for ship service. It is 28½ inches in over-all length and driven from any plant generating 110 volts direct current or from other similar sources of power supply. It is readily portable and designed for a single operator.

The Todd representatives are calling the welder to the particular attention of shipowners and operators.

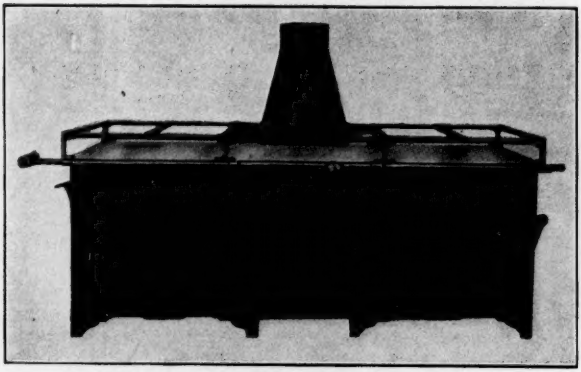
American Society of
Naval Engineers



PLANT MILLS DIRECTION INDICATOR DEMONSTRATED AT MARINE EXPOSITION.



SHIP TYPE ARC WELDING UNIT.



NEW OIL BURNING GALLEY RANGE.

NEW GALLEY RANGE.

Another feature of the Todd exhibit was a new type oil burning galley range which has been developed to meet the demands of owners for a range that would use inexpensive oils safely and with cleanliness. It is stated that the oil burner part of the equipment is of simple construction and requires little more attention than the burner on the ordinary domestic oil stove. The oil is fed to the burner by gravity, no mechanical aid being necessary for either atomizing the oil or for furnishing air to the burner.

The burner is placed in the center of the range with flues to right and left around the ovens, permitting even regulation of the temperature of the ovens. The oil supply line to the burner on the front of the stove is equipped with a sight feed oil box, in which the flow of oil can be observed.

The range is built of blue annealed mild steel of the highest grade and it is stated will withstand rust, corrosion, hard usage and wear. Castings are of the best grade of gray iron. All exposed sides are insulated with genuine asbestos mill board.

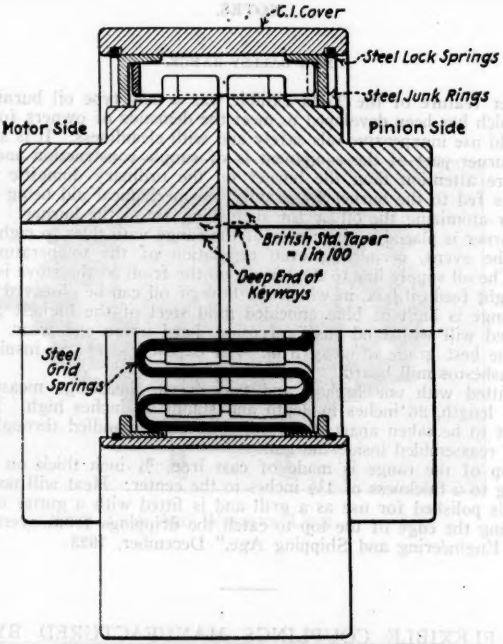
It is fitted with one firebox and two ovens, the range measures 98½ inches in length, 26 inches in depth and stands 36 inches high. Its design permits it to be taken apart in five distinct units, handled through a small door and reassembled inside the galley.

The top of the range is made of cast iron, ¾ inch thick on the ends, increasing to a thickness of 1½ inches in the center. Heat will not warp it. The top is polished for use as a grill and is fitted with a gutter completely surrounding the edge of the top to catch the drippings from overflowing.—"Marine Engineering and Shipping Age," December, 1923.

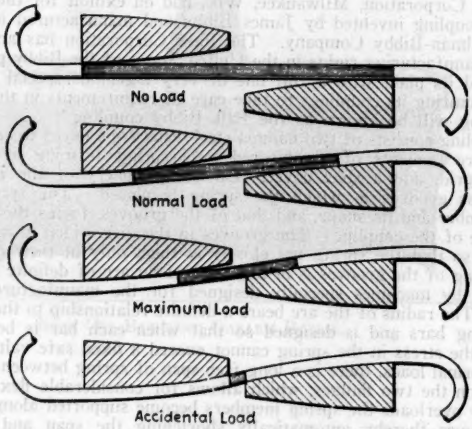
BIBBY FLEXIBLE COUPLINGS MANUFACTURED BY FALK CORPORATION.

The Falk Corporation, Milwaukee, Wis., had on exhibit for the first time a flexible coupling invented by James Bibby and manufactured in England by the Wellman-Bibby Company. The Falk Corporation has acquired the exclusive manufacturing rights in the United States of the Bibby patents and has equipped its plant with a full line of very ingenious special machinery for manufacturing its couplings to take care of requirements in this country. The coupling will be known as the Falk-Bibby coupling.

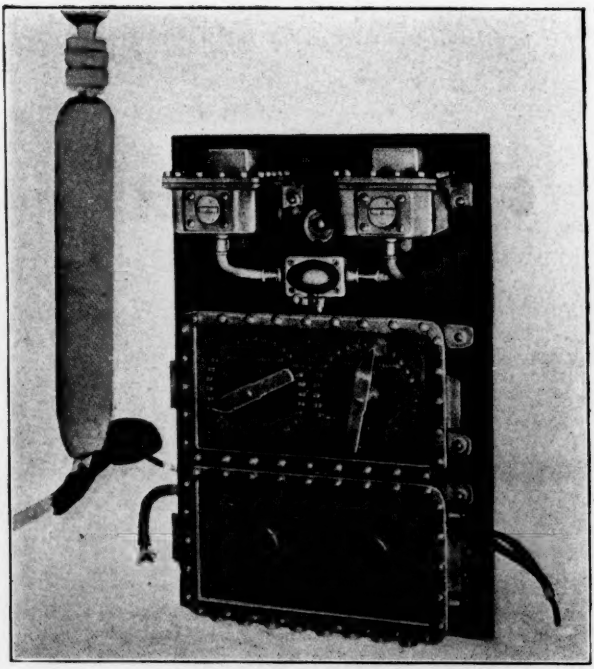
This coupling consists of two flanged steel disks (one keyed to each shaft), two or more sequents of a tempered steel spring forming a continuous cylindrical grid, and a steel cover. On the periphery of the flanges are pitched cross grooves in which the spring is placed. The spring is the flexible member and its shape, and that of the grooves, forms the characteristic feature of the coupling. The grooves in the disk widen inward toward each other, so that the spring fits closely in them only at their outer ends. This widening of the grooves is in the form of an arc of definite radius and is produced by machines specially designed for the manufacture of these couplings. The radius of the arc bears a definite relationship to the thickness of the spring bars and is designed so that when each bar is bent around this radius the stress in the spring cannot exceed a fixed safe value. Under light and normal loads, there is a long free span of spring between the points of support on the two flanges, which allows for considerable flexibility, but under heavy overloads the spring members become supported along the sides of the grooves thereby automatically shortening the span and stiffening the spring.



Sketch of Falk-Bibby Flexible Coupling



Action of Spring Under Variations of Load



ELECTRIC MARINE TEMPERATURE INDICATOR FOR REFRIGERATED SPACES.

It is stated that the coupling will compensate for want of alinement of the shafts without setting up cross pulls as occur with belt type couplings. The amount of eccentricity which the coupling will accommodate is more than that caused by worn bearings before they require relining.

The flexibility of the coupling was demonstrated by a remarkable exhibit at the Exposition. A centrifugal pump was mounted on a tank, and driven through a Falk-Bibby coupling by a 5 horsepower motor. This motor was mounted on a plate which in turn was swung sideways so that during the operation of the pump at full load the centerline of the motor shaft was slowly swung sideways up to 10 degrees each way out of alinement with the pump shaft. In spite of this tremendous misalinement the set ran very quietly.

The Falk Corporation claims for the coupling a torsional resiliency which enables it to smooth out bad running conditions.—"Marine Engineering and Shipping Age," December, 1923.

TEMPERATURE INDICATOR FOR COLD STORAGE COMPARTMENTS.

The marine electric thermometer which has been developed by the Wilson-Maeulen Company, 383 Concord Avenue, New York, for many years manufacturers of a high grade of electric thermometers and pyrometers, was demonstrated at the exposition.

This thermometer is an apparatus with which the temperature of a number of stations can be determined within the cold storage range. The apparatus comprises two dials, the one a temperature dial reading from 10 to 60 degrees F. and the other a station selector switch of 30 points. These two dials are mounted on a suitable panel and below them is a junction box. Two galvanometer indicators are mounted above the two dials, one being a spare. A separate water-proof switch is thrown to connect either indicator into the circuit.

Any number of electric thermometer bulbs (up to 30 maximum) may be located at suitable points where temperature is to be measured. Each thermometer bulb is connected to the indicator panel with a continuous armored cable. The temperature indicating dial and station selector switch mechanism is mounted under the cover in a box casting of marine bronze; operating spindles of Monel metal extending through stuffing tubes to the indicating dials on the front. Connecting wires from the mechanism compartment pass through a stuffing gland at the lower side of the case and enter the upper side of the separate junction box casting where the electric connections are made to the cable from the thermometer bulbs. The galvanometer indicators are fitted in individual marine bronze cases. The scale window is of thick plate glass suitably protected.

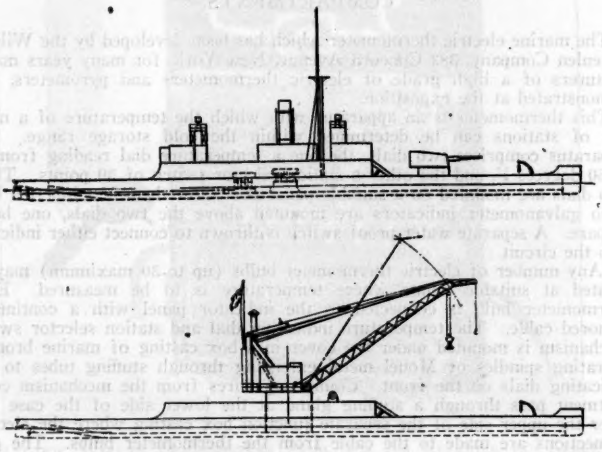
These indicators respond to less than one-tenth of one degree F. change in temperature of the thermometer bulb and are necessarily sensitive. The galvanometer indicators are of the moving coil type and are built with only one pivot which is located at the geometric center of the coil and which is also at the center of gravity of the movement. This feature renders the indicator readings practically independent of mechanical vibration and of ship roll.

To operate, turn the station selector switch to the desired temperature point (each point being indicated by a positive click). Turn the temperature dial until the galvanometer indicator index deflects to its zero. The number at which the temperature dial then points, indicates the temperature of that particular bulb.—"Marine Engineering and Shipping Age," December, 1923.

AN INTERESTING CONVERSION.

Some Notes of the ex-Monitor Crane Ship "Humber."

We have alluded previously in these columns to the conversion of obsolete warships into hulks upon which cranes could be mounted, and the case in point was the old American battleship *Kearsarge*, which was converted some little time ago into a floating crane for naval purposes. Another interesting example of a similar conversion is at present to be found in home waters in the shape of the ex-monitor *Humber*, which is at present being used as a floating crane pontoon by the Upnor Shipbreaking Company near Rochester; at the time of writing she is moored alongside the ex-super dreadnought *Monarch* (of the *Orion* class), which her owners are engaged in breaking up. The *Humber* has had a somewhat chequered career; she and two sister vessels were launched in 1913 at the Barrow shipyard of Vickers Ltd., as



The Monitor "Humber," Before and After Conversion.

river monitors for the Brazilian Navy, and as such they had an armament of two 6-inch guns and some small quick-firing weapons. They had the following dimensions and particulars:—Length, 265 feet; breadth, 49 feet; depth, 8 feet 6 inches; mean draught, 4 feet 6 inches; displacement, 1,850 tons.

Propulsion was effected by means of two sets of vertical triple-expansion engines taking steam from two Yarrow water-tube boilers. The vessels were taken over by the British Navy soon after the outbreak of war in

1914, minor alterations were effected, and they then did their first active service on the Belgian coast. After the armistice they were all three sold out of the service, and the *Humber* eventually went to Frank Rysdjk's Shipbreaking Company, Holland. The ship, however, was kept for shipbreaking purposes but not broken up herself, and up to the beginning of this year was still complete; then, however, her main engines and boilers were removed and part of the main deck and bulkheads were taken out to make room for a big gun turret from the ex-German battleship *Oldenburgh*. From the gun turret were removed armor plates, the platform behind the guns and gun mountings, &c.; but the engines for turning were left. This particular gun turret was selected because of its easy movement, the gun turret turning on a ball race of about 24 feet diameter. On the turret one of the big cabins from aft on the deck of the *Humber* was arranged as engine house, a new gib was made at the Penn & Bauduin Engine Works, Dordrecht, Holland, who also assembled the small and big winch, made the boiler, tackles, &c., and put the crane in working order. An upright boiler with 200 square feet heating service and 120 to 160 pounds pressure was placed in the cabin. In order to give steam for the winches a main steam pipe was laid to the center of the crane and along the ship to give steam for the steering gear, capstan anchor winch, &c.

We illustrate in profile the *Humber* as she was, and as she is at present, and we also show some views of the crane at work at Upnor.

The crane itself is capable of lifting 50 tons at a radius of 30 feet, and since it is a ship-breaking crane it is perhaps natural that it should be composed, as we have seen, of definite pieces of machinery taken from various vessels which have passed through shipbreakers' hands.

The barbette upon which the crane is mounted is fixed to the ship's tank top through a hole cut in the superstructure deck, and the house for the crane machinery, which is that removed from the aft end of the superstructure deck, contains a turning engine, a small 10-ton single purchase winch, derrick engine and generator. The turning engine is a small single cylinder originally used for driving a fan on the ex-German battleship *Rheinland*, working at 120 pounds per square inch. The small winch comes from the Naval Store Officer, Haulbowline Dockyard; the main crane engine collectively is new but it is fabricated from portions of ex-German engines; the derrick engine is a boat hoist from a German battleship, and there is also arranged in the cabin a small steam-driven generator from the "24"-class sloop *Bend Or*. This is of the type supplied by W. H. Allen & Sons & Co., Bedford, and, driven by a compound engine, gives 220 volts at 500 R.P.M. The boiler, of vertical type, is the only new portion of the machinery, and it is of Dutch make. At present the crane is controlled from the cabin, but arrangements are in hand whereby the control can be carried out from the cabin top. This is being accomplished by means of lever controls taken from the shell hoists on the *Orion*. Most of the *Humber's* cabins are in use as store rooms, &c., while her wardroom has been converted into a forge. All the main propelling machinery has been removed, but some of the auxiliary machinery pumps, generators, &c., is being retained and brought into working order. The crank and thrust shafts have been taken out, but the tail shaft remains. The crane is capable of lowering her gib flat down so as to make her seaworthy; her main engines, however, have been taken out, so she has no powers of self propulsion.

The other conversion to which we have drawn attention, that of the *Kearsarge*, is probably a more finished job than that of the *Humber*, since the former is intended definitely for naval service and the latter for scrapping service; the *Humber*, nevertheless, is ending her active career in a useful manner. "Shipbuilding and Shipping Record," December, 1923.

FACTORS IN THE SPONTANEOUS COMBUSTION OF COAL.

By O. P. Hood,* Washington, D. C.

This paper discusses the phenomena incidental to the self-heating of coal when subjected to change in environment and analyzes the effect of the self-heating on the piling of coal. The author states the fundamentals to be observed in storing coal with the minimum danger of spontaneous combustion.

In order that the engineer may intelligently consider the phenomena of spontaneous combustion of coal, he must receive from both chemist and physicist some general ideas about the coal substance, about the character of coal surface, about the atmosphere in which it may be immersed, and about slow combustion. The coal substance is extremely complex in its chemical relations. Carbon, hydrogen, and oxygen products of fairly definite chemical combination have been brought together in ages past under conditions where rearrangement, exchange, and elimination of elements have progressed at first rapidly and then at rates infinitely slow, until a practical equilibrium has been attained in the substances we find in the ground as coal. Change the surrounding condition, however, and recombinations may begin again. These may be very slow at normal temperatures, but at elevated temperatures they are rapid, and we call the process combustion.

A particle of coal within the mine has for its immediate neighbor a similar particle with which it has exchanged molecules, perhaps, and suffered common losses, until further reaction has practically stopped. This particle, removed from the mine, is surrounded by air from which it had been shielded for ages, and its moisture, temperature, and pressure environment become different.

We should expect considerable variation in coal, since the original vegetation from which it came varied in composition and was laid down in varying proportions, and its environment through the long ages has differed from place to place. Therefore the final equilibrium attained must be different in each case, and we have our anthracite, our bituminous, and our lignite coals.

ATMOSPHERE REACTS WITH FRESHLY BROKEN COAL.

When mined it is the freshly broken coal surface that experiences the greatest change and which finds its equilibrium most seriously upset. The boundary between the coal and the air looks smooth, perhaps, but when we apply the conceptions of the chemist the surface must be a jungle in which gas molecules become entangled, condensing on the surface in great numbers. The surrounding atmosphere may carry not only nitrogen and the active oxygen, but also vapor of water and other gases. The temperature will also change. Powdered coal sealed in a bottle with air gradually takes the oxygen of the air into combination, reducing the pressure in the container. Some CO_2 is formed, but not enough to account for all the oxygen. There is slow combustion, as we know it, and other reactions less definite and less stable. Various loosely held oxygen relationships are established on and in the immediate surface. Some coals will take up as much as 6 per cent in weight in this process. Entertaining this point of view it is not surprising, therefore, that there is an attempt to reestablish chemical equilibrium at the fresh surfaces, and that in these recombinations heat may be given off. Small amounts of heat may be generated in other ways. With the coal substance are minerals, and these also find themselves in

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strange environment and proceed to change. Heat may be generated from other than chemical rearrangements. If very fine silica sand be slightly moistened with water, heat is generated. There is no chemical change, but the deposition of moisture on the great extent of curved surface in some way generates a small amount of heat.

To sum up, we can expect a fresh broken surface of coal to be chemically active in some way, seeking to establish equilibrium under new conditions. The amount of the activity will vary with the particular coal, the amount of surface, and the environment. It will be rapid at first, and finally be so slow as to pass out of our interest. These changes may develop heat; they may add to the weight, and may finally reduce the weight by inducing combustion. The principal source of heat is the coal substance itself, whatever may be credited to the usually small percentages of associated minerals. Being a surface phenomena it will become noticeable only when the surface is large.

IN CHANGING ENVIRONMENT, COAL IS SELF-HEATING.

The rate of these chemical readjustments is greatly increased with increase of temperature. Chemists say that, generally speaking, the rate of chemical combination doubles for each 10-degree rise in temperature. Coal at ground temperature, when removed, is apt to be sent into warmer surroundings. If the surroundings are such that the heat generated cannot escape, the process becomes self-aggravating, with an increasing acceleration, so that very small heat quantities following this law in time become large. As the temperature rises new reactions also become possible, involving other constituents of the coal substance. J. D. Davis, of the Bureau of Mines, has devised an adiabatic calorimeter which provides an environment for coal which follows exactly the momentary temperature of the coal. Fine coal through which oxygen of the same temperature is made to flow rises gradually in temperature from 150 degrees F. until a critical point is reached, when the temperature rise is greatly accelerated. There is an elbow in the plotted temperature curve. This critical point is different for different coals, but is around 185 degrees F. In this device coal can be caught in the act of self-heating, rates can be plotted, and comparisons of behavior made.

When a coal surface is elevated in temperature above that of its surroundings it will lose heat by conduction, radiation, and convection. The body of the piece will itself be heated by conduction. Obviously, if the mass is large compared with the surface, as in coarse coal, the rise in temperature of the mass will be small as compared to the condition of fine coal where the total surface is large compared to the mass. Radiation at these small temperature differences is a small factor in the case. Convection is believed to play a considerable part in the problem. Air, vapor, and gas currents normally move across a coal surface, removing heat and carrying it elsewhere, and a temperature equilibrium is soon established at a slight elevation above that of the surroundings. In a pile of coal these movements are usually present. From 25 to 45 per cent of the volume of a pile is void spaces between coal particles, through which a comparatively free movement of air is possible when the pieces of coal are of appreciable size. A light wind pressure would change the air in the pile many times daily. If, however, the particles are quite small although the void percentage may be the same, the resistance to flow of air would be great and much less exchange of air and heat removal would follow. The ordinary daily barometric and temperature changes produce a breathing in such a pile that would exchange air, and if any portion becomes perceptibly warmer a chimney effect is also possible. These vagrant air movements within a pile are beyond computation, prediction, or practical measurement, but their existence determines largely whether we shall have a dangerous heating in a pile of coal or

not. If the movement of air be reduced to zero, the oxygen is soon completely engaged with new relations and the very small rise in temperature is stopped. If there is a considerable movement of air, any heat generated is carried away. There is therefore some rate of air movement too slow to carry heat away but sufficient to keep up the supply of oxygen and produce the maximum heating effect. The problem of coal storage is to prevent this condition, or if it exists, to discover it before a critical temperature is reached, and rearrange and cool the particles at the local point of heating.

COAL PILES PRESENT PECULIAR VENTILATION PROBLEM.

A conical pile of run-of-mine coal made by dumping from one point will have a central core of small-sized particles. Air exchange through this will be extremely slow. With such handling coal sizes are classified, and will grade from the finest in the center and top to the coarsest on the bottom and lower flanks where there is ample ventilation. Between these extremes, part way up the flanks and below the surface, there is likely to be a most favorable condition for spontaneous combustion, where the coal is fine enough to give a large surface of fresh broken coal and the ventilation too low to carry away the heat and yet sufficient to keep up the oxygen supply. The hazard is thus greatly increased by allowing this classifying action in building the pile.

The part that moisture plays in this problem is of interest. A distinction should be made between the moisture considered by the chemist and moisture as known to the operating man. In the one case water vapor may play a part in the chemical drama, perhaps being necessary to some reactions, and enter into the problem of swelling mineral crystals that break up the coal into finer sizes. To the operating man moisture means something he can see, a heavy rain on a car of fine coal, or perhaps drenching a pile of coal to cool it off. The latter effects are believed to be largely physical and mechanical. Fine coal will hold 15 or 20 per cent of free water, and such coal is practically impervious to air currents. The locomotive firemen wets his fine coal in order that the draft shall not at once blow through the coal. A dry pile which may be sufficiently ventilated may be partially sealed if wet, and reduce the ventilation to a dangerous point. The conclusion often reached is that wet coal fires easier than dry coal, but the conclusion should be that the ventilation was so restricted by an impervious blanket as to furnish favorable conditions for the accumulation of heat. Putting water on a hot part of a pile only seems to furnish a good carrier of heat to other parts of the pile, and to disturb ventilation, unless large quantities are used and the pile drenched. Even here it is possible to have the under part of a large coal piece glowing while a heavy stream of water is shed from the top as from the roof of a house.

PRACTICAL COAL STORAGE.

The application of these thoughts to practical coal storage lead to the following conclusions, which seem to agree with best current practice.

There must be no heat added to the coal from outside sources, such as hot walls, steam pipes, oily waste, etc. If coal can be got into the pile in pieces that will stay on a ¾-inch bar screen there will be no heating. The pile may be of any height provided there be no fines. Where mixed lump and fine coal must be stored the pile should be so built as to avoid segregation of sizes. The production of fresh surfaces by breakage just before going into storage, predisposes to spontaneous combustion unless the crushing is so fine and the packing of the pile so dense as to largely exclude air circulation. Coal should be so stored that its temperature conditions can be daily inspected. When any portion reaches a temperature of 140 or 150 degrees F. there is a high probability that within a few days or weeks

a destructive temperature will be reached. If the temperature reaches 160 or 180 degrees F., there is almost a certainty that a destructive temperature will be reached. The best remedy is to move the warm coal so that it may cool.

The possibility of quick removal should be considered in storing coal. This factor, rather than any tendency to heating, determines the desirable size of pile and its height. The tendency to heat differs in different coals, and experience is so far the best guide in determining this difference.—"Mechanical Engineering," December, 1923.

THE USE OF WELDING IN POWER-PLANT PIPING.

By Lewis J. Sforzini.

Welded pipe lines—but recently a curiosity—are now in use and under construction in power plants all over the country. The author, who has made extensive use of welded piping installations for a variety of purposes, here gives the essence of his experience for the benefit of engineers not yet fully acquainted with the time- and money-saving developments in this field.

The rapid development of economical methods of welding by both the oxyacetylene and the electric processes, which began near the advent of the world war, has brought these forms of welding into extensive use in the power-piping industry. Today there is hardly a single pipe-fabricating concern that does not employ this type of welding in some way or other in the fabrication of its product. Besides its employment by the fabricators, it is used as an economical or expedient method by the power plant itself in making alterations and extensions to existing piping systems. It is the purpose of this article to indicate how the piping designer or the power-plant operator can use welded piping to advantage for certain conditions.

In high-pressure piping systems, in which class may be placed all those conveying steam, water, air, brine, ammonia and other fluids at pressures above 30 pounds, welding may be used to give compactness, to reduce the number of joints (and hence avoid some of the potential leaks), to minimize radiation losses by doing away with flange radiating area, to obtain lower first cost of piping under certain conditions, to obtain quicker delivery on pipe with welded outlets over that obtainable on special fittings and to reduce the cost of pipe covering under certain conditions, particularly in low-temperature work with brine or ammonia where cork is used. In addition to the foregoing the closing length of a pipe run can, where time is an important factor, be measured in the field and the pipe burned off and the ends welded together without the necessity of sending away to have the pipes flanged or threaded the proper length. The present trend toward higher steam pressures and temperatures is leading to the elimination of as many gaskets as possible and to the sealing of steel flanges by welding.

Of the foregoing advantages, the reduction of the radiation area by eliminating flanges is ordinarily of minor importance. With long pipe lines, however, this factor is worth considering. For instance, in a recently installed outdoor 12-inch high-pressure steam line about 5,000 feet long, there were 250 welded joints. A pair of 12-inch extra-heavy flanges has a total radiating area about 3½ square feet greater than that of plain pipe, with a loss of 100 B.T.U. per square foot per hour from covered areas, or 350 B.T.U. per pair of flanges. With steam continuously in the pipe, the saving by omitting flanges would be about 35 tons of coal per year. In addition, the necessity for expensive flange covers would be obviated.

Fig. 1 shows three of the common line welds used to avoid flanged joints on steel pipe. The simple butt weld A can be made either by oxyacetylene or electric welding. In making this weld, the ends of the pipe are first

FIG. 1.—TYPES OF LINE WELD USED TO REPLACE FLANGES.

scarfed at an angle of between 30 and 45 degrees. The ends of the pipes are then brought together until they nearly touch, and aligned, after which a weld is made, working gradually around the periphery until the depression is completely filled. If this weld is made by a conscientious and expert operator under proper supervision, it can be used successfully, as has been proved in numerous installations for steam at high pressures and superheats. However, some engineers are reluctant to use this joint without some added security against failure.

The combination butt-and-sleeve weld B can also be made up by either oxyacetylene or electric welding. The butt weld is made up as just described, after which the welded portion is ground off flush with the pipe by a portable grinder. A sleeve is then slipped over and welded at the ends as shown. The sleeve here acts as a reinforcement against rupture by pressure and failure by expansion stresses (in steam work). An experienced operator can weld a joint of this kind on a 16-inch pipe in about 3½ hours. If a sleeve is hard to procure in repair or alteration jobs, a screw pipe coupling with threads machined off, may be used.

The sleeve weld C is made by one fabricating concern, using the oxyacetelene process. About six inches of one end of each pipe is expanded by special machinery in the shop, after which four to six holes (depending on the pipe size) are burned through the expanded portion. In welding, the plain end of one pipe is slipped into the exanded portion of another and welded through the holes. The end of the expanded portion is then scarfed with the welding flame and a long weld made as shown. A rubber manufacturing company has a 14-inch high-pressure steam line about 3,500 feet long with this type of joint, and another manufacturing concern has a line with 250 such welds. An operator can make this weld on a 12-inch line in about 2½ hours. This joint, as well as those shown at A and B, can be welded from underneath when it is impossible to turn the pipe and weld from above.

In Fig. 2, A shows a 14-inch 250-pound steam header from an actual installation. This was an alteration job where the 25-foot 6-inch and 12-foot 6-inch dimensions were fixed by existing construction. The end 14-inch flanges went against flanges used before the "American Standards" for drilling were adopted, and had to be specially drilled. Delivery on this particular job was important. The whole header was fabricated and shipped by the fabricator one week after receipt of order, at a small fraction of the cost of the alternative construction B based on the use of fittings.

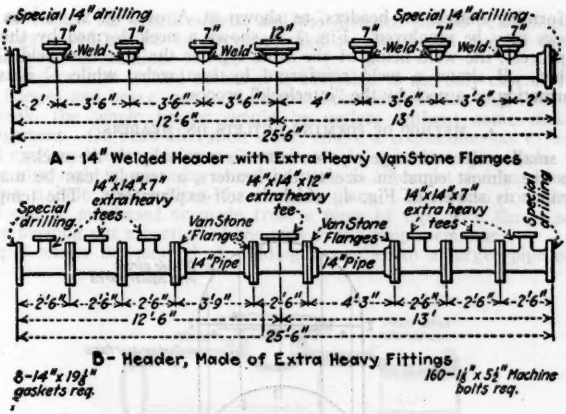


FIG. 2.—THE USE OF A INSTEAD OF B SAVED $500.

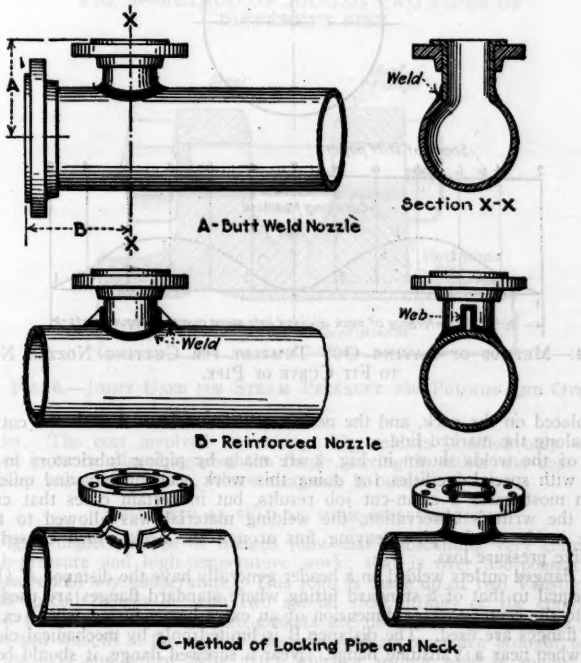


FIG. 3.—VARIOUS METHODS OF ATTACHING NOZZLES.

In forming outlets on headers, as shown at A of Fig. 2, various types of necks may be employed. Fig. 3 A shows a neck formed by the butt-weld process, the weld being of the same type as the butt line weld already described. B shows a weld reinforced by two webs, while C illustrates the formation of a neck by the "interlock" process.

METHOD OF FORMING OUTLETS ON HEADERS.

For small outlets on large pipe no curve is necessary on the necks. When outlets are almost equal in size to the headers, a templet can be made on stiff paper as shown in Fig. 4, which is self-explanatory. The templet is

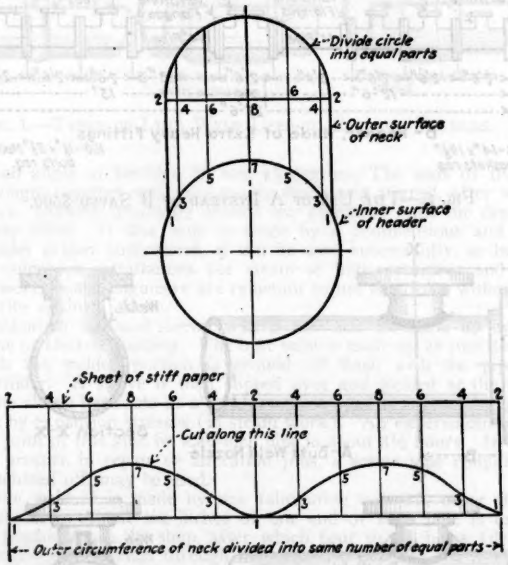

Divide circle into equal parts
Outer surface of neck
Inner surface of header
Sheet of stiff paper
Cut along this line
Outer circumference of neck divided into same number of equal parts

FIG. 4.—METHOD OF LAYING OUT TEMPLET FOR CUTTING NOZZLE NECK TO FIT CURVE OF PIPE.

then placed on the neck, and the neck marked and burned with the cutting torch along the marked line.

All of the welds shown in Fig. 3 are made by piping fabricators in the shops with special facilities for doing this work economically and quickly, and in most cases a clean-cut job results, but in certain cases that came under the writer's observation, the welding material was allowed to flow to the inside of the pipe, leaving fins around the neck which caused an excessive pressure loss.

The flanged outlets welded on a header generally have the distance A (Fig. 3 A) equal to that of a standard fitting where standard flanges are used, or equal to the center-to-face dimension of an extra-heavy fitting where extra-heavy flanges are used. The distance B is limited only by mechanical clearances when near a Vanstone flange. Near a screwed flange, it should be at

least 12 inches for small outlets, and the distance should be increased for the larger-sized outlets to prevent leaks at the thread due to distortion of the metal in welding.

On headers with welded outlets it is advisable to use only cast or forged-steel flanges and never cast-iron flanges, because were the cast-iron flanges to break, the whole header would be useless without some make-shift arrangement. On rush alteration work, where a connection has to be made to an existing header during a short shutdown, a neck can easily be welded to the pipe right in place by using the neck as a templet and marking, then burning a hole and welding the neck in place. The necks for alteration work can be purchased or made from a piece of pipe with flange screwed on, by burning out a portion of the pipe to the proper contour.

Fig. 5 shows the method of welding a smaller to a larger pipe near an

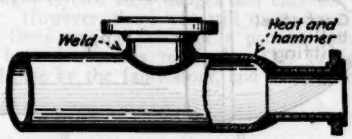


FIG. 5—METHOD OF JOINING TWO PIPES OF DIFFERENT SIZE

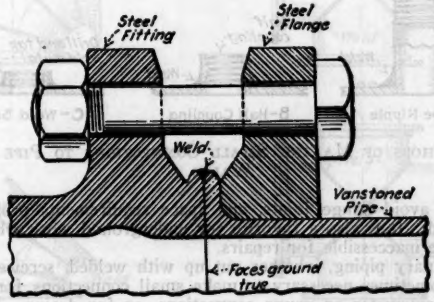


FIG. 6.—JOINT USED FOR STEAM PRESSURE 350 POUNDS AND OVER.

outlet. The cost involved in making this weld is justified only when a valve is to be placed against the flange, saving in either the cost of the smaller valve or in space, where clearance is needed.

WELD USED AS SEAL ON HIGH-PRESSURE JOINT.

Fig. 6 depicts a type of flanged joint that is becoming very common in high-pressure and high-temperature work; that is over 350-pounds steam pressure and any temperature. This joint is made up of two Vanstone ends with special flanges or with two special steel fittings or the combination of a flange and a fitting. No gaskets are used, but the faces are ground true and smooth in the shop. These finished surfaces are brought together in the field and bolted tight, after which a sealing weld is applied. This

joint does away with all gasket troubles by omitting the gasket. Further, since the bursting and tensile stresses are all carred on the bolts and not on the weld, the joint is efficient enough to meet the most stringent of safety requirements.

Another type of high-pressure joint used on steel fittings is shown in Fig. 7. This joint is used in steam or other high-pressure work when it

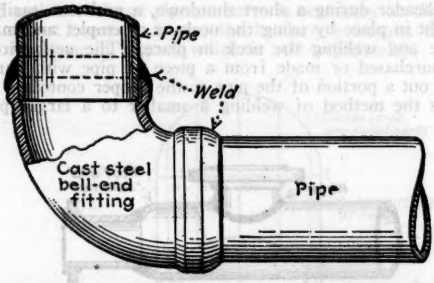


FIG. 7—HIGH-PRESSURE STEAM FITTING USED FOR TURNING SHARP CORNERS AND FOR UNDERGROUND WORK

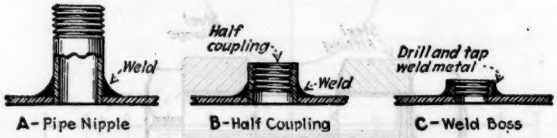


FIG. 8.—METHODS OF MAKING SMALL CONNECTIONS TO PIPE WITH THIN WALLS.

is desired to avoid flange joints, and space requirements prohibit the use of a pipe bend. It is also a favorite for underground work where a gasket joint would be inaccessible for repairs.

On all ordinary piping, whether put up with welded, screwed or flanged joints, it is sometimes necessary to make small connections for outlets, for drips, for thermometer or gauge connections, or for drains. Usually it is possible to tap fittings, valves or blind flanges for connections. For good work it is usual to limit the size to which a fitting is tapped to 1½ inches on standard fittings and 2 inches on extra-heavy fittings. The pipe itself may be tapped if the walls are sufficiently thick. A pipe-wall thickness of 5/16 inch permits of tapping holes up to ½-inch pipe size; ⅜-inch wall thickness permits pipe taps up to ¾-inch; with thinner walls or larger taps any of the welds shown in Fig. 8 may be used.

It is customary to test all welded, high-pressure piping at a hydrostatic pressure equal to twice the working pressure, after which all porous welds are made tight.

TESTING AMMONIA LINES WITH AIR.

For ammonia lines where there is even a remote possibility of the test water remaining in the pipe, water should not be used but the ammonia compressor should be used to pump air into the line until the pressure

is equal to twice the probable maximum condenser pressure. Leaks can then be detected by loss of pressure when allowed to stand for some time, the exact location being determined by applying a soap and water solution with a brush. Air bubbles will quickly show the leak.

Until a very few years ago the designer of low-pressure steam and vacuum work, in using large mains (16-inch or over), had the choice of either cast-iron fittings or fittings made up of riveted steel plate. For pipe he also had the choice of either cast-iron pipe, which usually came in 12-foot lengths with integral flanges, or steel pipe with riveted steel flanges on the ends. Cast-iron pipe and cast-iron fittings proved extremely heavy for certain installations, and the bolts used for making up the joints were also heavy from the standpoint of good design. In making up a run of cast-iron pipe, either a special length of pipe had to be procured as a filler piece or a dutchman had to be used, either of which proved expensive.

Steel pipe with light riveted steel flanges and cast-iron fittings proved a better combination. However, there was still room for improvement, as it was apparent that there was no need for a pair of joints every time an outlet, no matter how small, was required. This brought about outlets riveted to the steel pipe by the fabricators, and in some cases even riveted

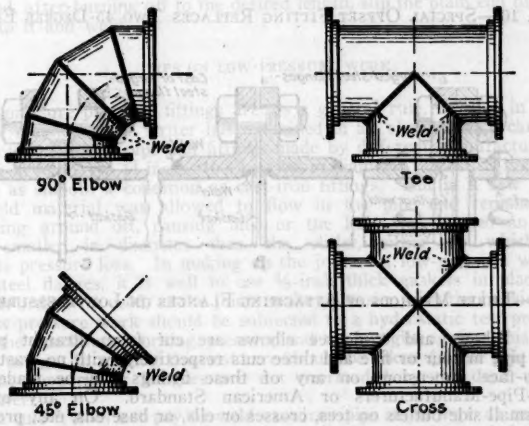


FIG. 9.—COMMON FITTINGS BUILT UP BY WELDING.

elbows and miscellaneous special fittings. The fabricator, in thus obtaining the whole order, was enabled to substitute lighter flanges than the American Standard in the form of the riveted-pipe-manufacturer's standard, except where connections were made to standard valves, etc., where the American Standard drilling was maintained. This lessened the cost to the power-plant owner. Recently, welding has been substituted for riveting on low-pressure steam fittings. Pipe is either rolled or welded together from steel plate. Outlets are welded onto the pipe. Elbows, offsets and special fittings are made up of welded pipe segments or from welded steel plate.

Fig. 9 shows how the common fittings are made up. The work is all laid out from patterns carried in stock by the fabricators for the standard

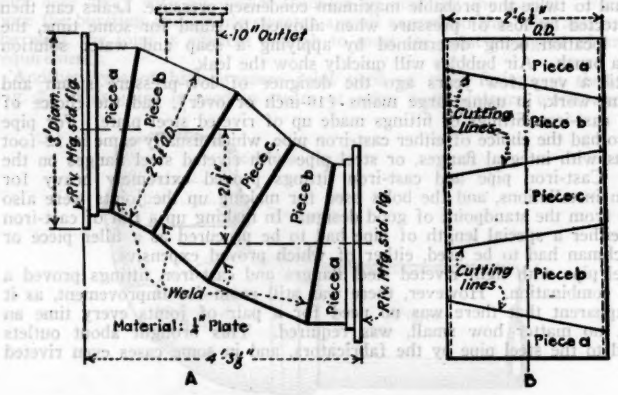


FIG. 10.—SPECIAL OFFSET FITTING REPLACES TWO 45-DEGREE ELLS.

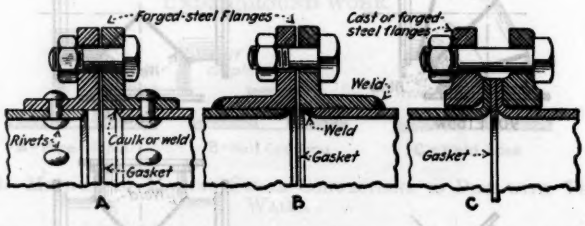


FIG. 11.—THREE METHODS OF ATTACHING FLANGES ON LOW-PRESSURE LINES.

fittings. Elbows and 45-degree elbows are cut from straight plate or straight pipe in four or five and three cuts respectively, with no waste. The center-to-face dimensions on any of these fittings can be made either Riveted-Pipe-Manufacturers or American Standard. On any of these fittings small side outlets on tees, crosses or ells, or base ells, etc., present no difficulties.

COMPLICATED FITTING EASILY MADE BY WELDING.

In Fig. 10, A is a special fitting used by the writer and originally laid out for two standard 30-inch 45-degree elbows, the same dimensions being maintained in the welded fitting. B shows how this fitting was cut from 30-inch pipe with four cuts and no waste. About a year after this offset was installed, it was found necessary to put in a 10-inch outlet as shown, which was easily done by burning a hole and welding a nozzle on. Had a cast-iron fitting been used, this would have been impossible without a new fitting.

Three ways of attaching the flanges to the pipe or fitting are shown in Fig. 11, where A is a steel flange riveted to the pipe and either calked on edge or calked by welding. In B a steel flange is welded to the pipe

along two lines as shown. The low-pressure Vanstone flange C does away with the difficulty of aligning work in the shop to have holes in opposite flanges in line. It has the same advantage as the similar joint for high-pressure work. These flanges are all made of cast or forged steel, and can be made up to American Standard or to Riveted Pipe Manufacturers Standard drilling. For the American Standard drilling the flange thickness is much less than for cast-iron work. In alteration work, if steel flanges cannot be obtained in time, a satisfactory substitute may be made by curving a steel angle iron to the proper radius and welding the ends together to form a ring.

The thickness of the pipe metal for low-pressure work can be from No. 16 gauge to ½ inch thick or over, depending on the diameter and the service, although for steam work for ordinary pipe diameters, ¼-inch thick walls is the general rule, this providing ample metal to resist internal and external corrosion were any to occur.

In a low-pressure installation provision is made for pieces needed in the field to close a pipe run by making a pipe length 6 inches or 12 inches longer in the shop and having one flange on the pipe fastened to it, the other flange being shipped loose. After field measurements are taken, the pipe is burned or cut off to the desired length and the flange is then riveted or welded to it. Another method is to expand one end of the pipe in the shop and, after burning off to the desired length, slip the plain end of another pipe into it and weld.

TIPS ON LOW-PRESSURE WORK.

Low-pressure pipe and fittings are, as a general rule, finished in a workmanlike manner. The writer has examined in all about twelve carloads of low-pressure welded pipe and fittings made by different manufacturers, and varying in size from 14 inches to 42 inches in diameter. Most of the material was in as smooth a condition as cast-iron fittings. But in a few instances the weld material was allowed to flow in the pipe and remained without being ground off, causing fins, or the hole was burned an inch or more smaller in diameter than the outlet, either of which causes needless pressure loss. In making up the joints on low-pressure work with light steel flanges, it is well to use ⅛-inch thick gaskets in place of the 1/16-inch ordinarily used, as the joints make up easier with the heavier gasket. All low-pressure work should be subjected to a hydrostatic test pressure of twice the maximum working pressure and made tight against this pressure before using. In making this test care should be taken (if the pipe is large) that the supports or hangers are not overloaded by the dead weight of the water.

As a rule it does not pay to weld cast-iron pipe or fittings, as certain precautions which make the job expensive, such as preheating and the insertion of steel studs, must be observed to obtain a satisfactory job. The exceptions are in the case of broken large special castings where an extensive shutdown has to be avoided. In such cases the broken parts are brought together by shrinking links; then a series of small studs are inserted on each side along the crack. The crack is then grooved out, after which a weld is applied, forming a lacing network along the studs and completely sealing the openings.

On alteration work where it is desired to form an opening on a large cast-iron pipe or fitting, this can be done by procuring a flanged cast-iron nozzle with a steel calking strip, or a steel nozzle flanged to the proper radius. Then a hole is cut out by drilling a series of small holes at the point where the nozzle is to be located in the pipe, after which holes are drilled or drilled and tapped to correspond to the nozzle flange and the

nozzle is then riveted or patch-bolted to the pipe and calked. Where time is important, a nozzle may be made from a screwed nipple with flange at one end and a steel plate from ¼ inch to ⅝ inch thick curved and welded at the other end, as shown in Fig. 12.

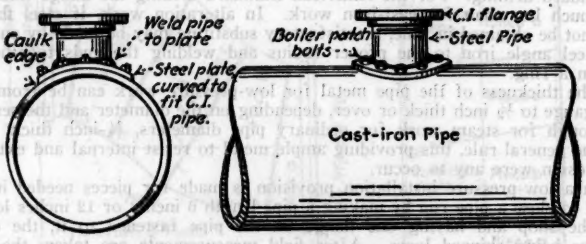


FIG. 12.—EMERGENCY METHOD OF FORMING NOZZLE ON CAST-IRON PIPE.

In conclusion, it may be said that while the time of the engineer or maintenance superintendent is too valuable to spend on doing the actual welding, he should understand the full possibilities of welding pipe, and it was with this end in view that this article was written. In large industrial plants there are nearly always one or more welders employed on general maintenance work, so that it is an easy matter to have pipe welded in the power plant. In an ice plant or the power plant of a public utility, the engineer can generally call on a reliable welding concern in his own community to do his work, provided he supervises the operations.—"Power," November 20, 1923.

HEAT BALANCE OF A POWER PLANT.

The purpose of the present article is to show by an actual example how a simple heat balance for a condensing steam plant may be worked out and represented by a diagram.

The final result is shown in the accompanying diagram, in which the flow of heat is represented by bands whose widths indicate the relative amounts of heat involved. Dotted rectangles are used to show the main groups of apparatus.

To simplify the heat balance, certain losses have been grouped. For example, all the boiler and furnace losses are combined, as are the generator and outside engine losses.

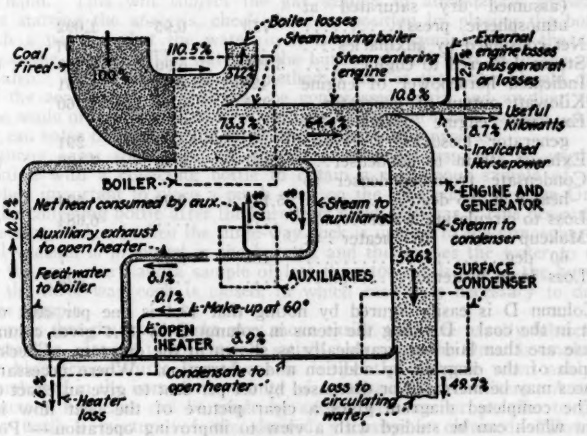
The boiler is fired with 13,400-B.T.U. coal and produces steam at 150 pounds gauge and 100 degrees superheat. An open heater supplies feed water at 205 degrees. Some of the steam goes to the auxiliaries, which exhaust to the open heater. The rest goes to the main engine, developing 428 I.H.P. and 255 kw. The engine exhaust passes to a surface condenser, and the condensate at 105 degrees passes to the open heater, where it mixes with the condensed auxiliary exhaust and a small amount of makeup water.

Turning to the table, the weights shown in column A are determined as follows: 1 by weighing; 2 and 3 by flow meters; 4 as the difference between 2 and 3; 5 by estimation from size and water rate of auxiliaries; 6 assumed

equal to 5; 8 by subtracting 5 from 3; 9 by computation from indicator cards; 10 from the switchboard wattmeter; 12 and 13 assumed equal to 8; 15 assumed equal to 4.

These figures obtained, the next step is to divide all items in column A by 750 (the weight of coal fired per hour) to get the weights per pound of coal fired, as shown in column B.

The next step is to figure the items in column C, which shows the heat flow corresponding to the items in B. Starting at the top and working down, the first item is the known heat value of the coal. Item 2 is the product of 8.10 by (205 — 32), which is the heat in one pound of water at 205 degrees.



SHOWS RELATIVE AMOUNTS OF HEAT INVOLVED.

The heat in one pound of steam at 165 pounds absolute and 100 degrees superheat is 1,252 B.T.U. This, multiplied by 7.85, gives item 3. To get item 4, add 13,400 and 1,401 to get 14,801 (the total boiler input) and subtract the useful output, 9,828.

Item 5 is the product of 0.95 by 1,252 the heat in one pound of boiler steam. To get item 6, assume that the auxiliary exhaust is dry saturated steam at atmospheric pressure, containing 1,150 B.T.U. per pound. Then $0.95 \times 1{,}150 = 1{,}092$ B.T.U. The difference between this and item 5 gives item 7.

Item 8 is 6.9 times 1,252. Item 9 is 2,545 (heat equivalent of a horsepower) multiplied by 0.57. Similarly, item 10 is the product of 0.34 by 3,412. Item 11 is the difference between items 9 and 10.

The heat per pound of the engine exhaust steam is not directly known, but item 12 may be taken as the difference between items 8 and 9. Item 13 is the product of 6.90 (105 — 32). Item 14 is the difference between items 12 and 13. Item 15 is the product of 0.25 by (60 — 32).

To get item 16, add items 6, 13 and 15 to get 1,603 (the total heater input) and subtract the useful output (item 2).

HEAT—BALANCE DATA AND RESULTS.

No.		A Lb. per Hour	B Lb. per Lb. of Coal	C B.T.U. per Lb. of Coal	D Per Cent of Heat in Coal
1	Coal fired	750	1.00	13,400	100.0
2	Feed water to boiler at 205 deg.	6,075	8.10	1,401	10.5
3	Steam leaving boiler at 150 lb. gauge, 100 deg. sup.	5,890	7.85	9,828	73.3
4	Boiler losses	185	0.25	4,973	37.2
5	Steam to auxiliaries	713	0.95	1,189	8.9
6	Auxiliary exhaust to heater (assumed dry saturated at atmospheric press)	713	0.95	1,092	8.1
7	Net consumed by auxiliaries	....	....	97	0.8
8	Steam delivered to engine	5,177	6.90	8,639	64.4
9	Indicated horsepower of engine	428	0.57	1,451	10.8
10	Kilowatt output of generator	255	0.34	1,160	8.7
11	External engine losses plus generator losses	....	....	291	2.1
12	Exhaust steam to condenser	5,177	6.90	7,188	53.6
13	Condensate from condenser to heater at 105 deg.	5,177	6.90	504	3.9
14	Loss to circulating water	....	....	6,684	49.7
15	Makeup water to heater at 60 deg.	185	0.25	7	0.1
16	Loss from heater	....	....	202	1.6

Column D is easily figured by noting that 13.4 is one per cent of the heat in the coal. Dividing the items in column C by 13.4 gives column D. These are then laid out graphically as shown in the diagram. Check each branch of the diagram by addition and subtraction. Where necessary the figures may be increased or decreased by 0.1 per cent to give an exact check.

The completed diagram gives a clear picture of the heat flow in the plant which can be studied with a view to improving operation.—"Power," October 30, 1923.

HINTS ON THE OPERATION OF THE ORSAT APPARATUS.

By Peter G. Dahl.*

In many cases, for example, when making a test for the combined boiler and furnace efficiency, it is desirable to analyze as many samples of the flue gases as can be obtained during the test. One should therefore be thoroughly familiar with the practical operation of the Orsat in order to be able to analyze the samples accurately and quickly. A few hints that have been proved to be helpful, are contained in the following statements.

The prevailing custom in bringing the water from the bottle up to the zero mark on the burette, in order to have 100 c.c. of gas at atmospheric pressure in the burette, is to open the three-way cock to connect the header to the atmosphere and then elevate the bottle slowly until the water rises to the zero mark, at which point the three-way cock is turned to shut off the connection between the header and the atmosphere. Should the water be allowed to rise above the zero mark before the three-way cock is closed, a sample of less than 100 c.c. of flue gas will be contained in the burette, and

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if the bottle should accidentally be lowered before the zero mark is reached, air will be drawn into the burette and the gases contained therein will be diluted, thus rendering the sample worthless. In both cases a new sample of gas should be drawn and analyzed.

An easy and sure way of obtaining the zero position is to draw a sample of gas, shutting off the gas supply immediately after the water in the burette has drained to a point just below the zero mark and then elevating the bottle to compress the gas until the water rises above the zero mark. Then pinch the rubber tube connecting the burette and the bottle with the fingers of one hand and place the bottle on its shelf. Gradually release the pressure on the gas by allowing the water to drain into the bottle until the water in the burette has dropped to the zero mark, at which point the three-way cock should be given one complete turn, using the fingers of the other hand. This will subject the gas sample to atmospheric pressure. Before starting the analysis, check the zero position by placing the bottle in such a position that the water in it is on the same level as the zero mark on the burette. The water in the burette should then be at the zero mark also. The advantage of this method is that if the water should drop below the zero mark, the gas may be compressed again and another trial may be made in less time than it would take to draw in a new sample. Also, no air can enter the burette and dilute the gases by this process.

In many cases some kind of water or steam-jet aspirator is used in connection with a collecting bottle to obtain a continuous sample of gas. It is then important to place a pinch cock on the tube connecting the Orsat with the collecting bottle after the burette is filled with gas. This precaution is necessary because, when the three-way cock is opened to the atmosphere, a partial vacuum is produced in the burette, and this causes the water to rise above the zero mark and a sample of less than 100 c.c. is left in the burette when the three-way cock is closed, in which case it is necessary to draw another sample.

In order that the glass cocks may move easily, they are usually lubricated with vaseline. Its use is not entirely satisfactory when the Orsat is employed where high temperatures prevail, as is frequently the case when analyses are conducted in the immediate vicinity of uptakes and economizers. A more satisfactory lubricant can be made by adding beeswax or paraffin to pure rubber until a mixture of the desired viscosity is obtained.—"Power," October 30, 1923.

HOW TRIAL SPEEDS ARE AFFECTED.

Long experience with the running of ships on measured mile trials causes some engineers to be very watchful over details which may well affect the result. One of the points which calls for constant attention is that the steering should be skilfully accomplished. It is on record that a difference of one-half knot was shown by a full vessel when a change of steersman was made, the revolutions and steam pressure being exactly the same, but a better course maintained. Care must be taken when approaching a measured mile that the vessel has completed her turn round and that a straight course is laid; lack of consideration of this point may affect the result appreciably. In cases in which the guaranteed speeds are difficult to achieve, due consideration of the tidal effects may help to ease the task and even one double run with the tide receding and flowing will help the mean result. One of the most curious causes of a diminution of speed during a prolonged trial was bad ventilation of the galley. The engineer in command of the trial party noticed a perceptible change in steam pressure and consequent fall in number of revolutions. On investigation, he found a discontented set of firemen, who complained of lack of proper food. He pursued his inquiries

further and found the galley stewards enduring intolerable heat. Since then this chief has made it a point to see that the galley in every ship which leaves his establishment is thoroughly well ventilated. One would not readily appreciate the possibility of bad ventilation of the galley affecting trial results, but such a case actually was experienced.—"Shipbuilding and Shipping Record," November 1, 1923.

WATER IN TURBINES.

A writer in a technical contemporary discussing the failures that have occurred in turbine installations on land, states that as a result of his investigations he finds that the majority of these are due to the accumulation of water in the turbine casing. The number of failures with marine turbine sets is happily very few, but this may be largely due to the fact that designers fully appreciate the danger that may follow if water collects in any part of the casing, and they take steps to ensure that all water shall drain away as quickly as it is formed. It is impossible to prevent the formation of a certain quantity of water in a turbine casing even when highly superheated steam is used, but by the provision of a channel at the bottom of the casing and by installing the turbine so that it slopes gently towards the exhaust opening the water should drain into the condenser almost as quickly as it is formed. It must not be forgotten, however, that the clearance between the blade tip and the casing is very small, and it is probable that the water of condensation is whirled round with the blades, and that in consequence it does not tend to drain into the passage provided. To overcome this difficulty it is suggested that the drain passage should be shaped like the guide vanes of a turbine pump, according to the direction of rotation of the turbine, so that the water as it is whirled round with the blades would at the bottom of the casing enter between the guide vanes and thus pass to the condenser. In this way the risk of an accumulation of water would be materially reduced.—"Shipbuilding and Shipping Record," November 1, 1923.

YES-MEN AND NO-MEN.

By Fred Saunders.

Will some psycho-analyst answer the question: Why do sub-executives, foremen and assistants, become "yes-men" when the big boss asks their views on certain problems?

There are a number of questions to answer, really. Why does an executive, who never hesitates to tell his honest views to other executives on his same level, give the big boss a dishonest opinion? He wants to flatter the general manager, for example, by agreeing with him. Whereas, the general manager would rather have the man disagree.

Fortunate, indeed, is the organization which contains several "irreconciliables," "chronic kickers"—no-men instead of yes-men. Of course, they should have behind their opinions substantial reasons. That's the kind of men referred to here.

In a certain organization that comes to mind at this point, the biggest question annually is the price to be paid for raw material. That price is based on a definite contract entered into months before the raw material becomes available, and from a year to two years before the manufactured product can be sold. The entire year's operations depend, first, upon obtaining a large volume of raw material to insure large volume factory production and low cost, and second, upon the price paid for the raw material.

It is a situation demanding the very best thought—the most honest thought—in the organization. Yet a certain number of the sub-executives can be depended upon to try and guess what the management thinks is a fair price and then, regardless of their own views, which the management really needs in order to arrive at a sane final decision, these sub-executives will "yes" everything the general office heads suggest.

Or, take questions of public policy in a far-flung organization having factories in many states, whose general office relies upon the local executives for guidance in obtaining the public's good will in the factory communities. It may be a matter of local bank deposits and the loss of the banker's good will by insistence from the general office upon bonds and personal signatures of the bank directorate. Or it may be the problem of local purchases instead of centralized buying.

If the "yes" executives think the general office prefers to do all the buying or that the general office heads will oppose the relaxation of safe banking measures, the "yes-men" swing behind the big bosses without giving them the benefit of honest views gleaned from close contact with the problems.

Please, Mr. Psycho-Analyst, do not blame it all on the big bosses. Do not reply that they fail to inspire the confidence of the sub-executives. Nor blame it on "human nature." That is what we want to know more about. And, above all, do not tell us to get rid of the "yes-men" and get some real, constructive sub-executives. Management is doing the best that it can with the human nature that is found in foremen and local managers. Some of these latter who try to discover which way the wind blows from the big bosses are technically proficient. Just because they are weak in one aspect of character is no reason for discharging them. And especially when there are no able successors ready to take their places.

There is an old wheeze about "never ask any question that you can not answer." We can not answer *why* are yes-men, but we may be able to throw a little light on how to handle them. Probably most big bosses know the breed and how to use them, and if any yes-men are reading this it may help them to buck up courage enough to oppose the big boss if there are good reasons therefore.

I know a very successful head of one of the world's largest corporations in its line, who has sacrificed a large part of his natural ability to mix with folks because he must keep his opinions to himself in order to obtain the opinions of his subordinates. He is, and in his position he needs to be, in constant fear of the yes-men. They do not learn what he knows and thinks about a subject or a question of policy in the company until he has exhausted the knowledge and opinions of those under him.

He has even gone so far as taking the opposite viewpoint to his preconceived notion in order to get all the reasons the yes-men have for doing, perhaps, the wrong thing. It sometimes works to fortify his original opinion on the subject or sometimes convinces him that the yes-men are right. But it gets him information and opinions, for what the latter may be worth.

Despite the reams of hog-wash printed about the faculty some managers of industry have for gaining the confidences of the least of their employees, let's be frank about the commonality of our big bosses. They are in a difficult position with respect to their foreman and sub-executives. It is hard for the big boss to get close up to his subordinates. This is due quite as much to the embarrassment and character of the subordinates as it is due to the boss' shortcomings.

To bridge this gap, a very successful manager of a large industry has a method which, while it again does not answer the why of yes-men, obtains their honest opinions. The method is based on the well-known fact that yes-men talk frankly to those whom they believe to be their equals. Therefore, this manager has a few trusted men who have both his confidence

and that of the sub-executives. The latter criticise the management freely to the trusted men, criticise policies, suggest improvements and otherwise function as they should. But they function thus to the big boss' trusties and not to the boss himself because in his presence they are either tongue-tied, barren of ideas, or yes-men. And they do not know that the trusties carry the honest messages of the sub-executives to the big boss, without prejudice to the yes-men's standing in the organization or without "spying" in the disagreeable sense of the word. It is just a natural condition that is being solved in the only practical way the boss knows.

The yes-men think they are playing "politics" by anticipating the master's voice instead of using their own vocal powers and overcoming their tendency to make a rubber stamp of themselves. They hope to climb the ladder by cashing in on the boss' bump of self-esteem, fed by the sub-executives' flattery in ready agreement with the opinions of the "chiefs."

And how about the no-men? We are not discussing here the type who act on the theory that "whatever is, is wrong." We are thinking of those who act on the theory that whatever is may be bettered. The difference between these types is the differnce between grouch and "guts."

It is not so strange that the best kind of no-men are young, both in point of age and in years of service in the organization employing them. There is one such that comes to mind who, although an assistant district superintendent of a highly technical staff, roams into the realms of sales, advertising, welfare and other branches of the business. Nothing is "foreign" to him, except a spirit of yessing whatever the boss thinks because it is the boss. He is always collecting statistical material, writing special reports—all unasked by his chiefs. His ear is close to the ground of the rank and file. They tell him their troubles, which they wouldn't think of telling to the higher-ups.

Frequently his reports to the management are just the opposite of what the men he reports on led the management to believe was their viewpoint. That is one of the worst features of yes-men. The management is up against it to know what they really believe. And if the management should adopt a line of action differing from the yes-men's guess of what the management would do, the yes-men are placed in the position of carrying out policies which they do not approve. However, a yes-man is a versatile fellow. His mind is flexible. As often as not he will enter heartily in the project he wrongly anticipated.

The good no-man is the sort who, when shown that his objections are not meritorious in the light of the greater information he obtains, enters into the management's policy not only with versatile vim but with intelligence. He has the "guts" to admit that he was wrong. He gave his honest opinions to the higher executives both because they were real opinions and because he was honest.

A noticeable trait of good no-men is that when they do not know, they admit it. The yes-man, if he doesn't know, tries to find out what the management thinks and then he yesses all over the place. He never admits that he doesn't know.

How do they get that way? Maybe some psycho-analyst can tell.—"Industrial Management," December, 1923.

A NOTE ON MAIN STEAM PIPES.

In the early days of high-pressure steam and the triple-expansion reciprocating marine engine, main steam pipes were made almost exclusively from copper sheet—the longitudinal joint being a brazed lap weld. The solid-drawn copper pipe is a later development, and is today regarded by many authorities as the most suitable pipe for saturated steam of working

pressures up to 180 pounds per square inch. Lap-welded copper pipes have sometimes failed at their longitudinal joints. That, at least, is generally the weakest section for bursting purposes if the pipe be considered as a thin hollow cylinder subjected to simple tension by the application of internal pressure. The solid-drawn copper pipe eliminates this possible source of danger and brings the safety factor up to the point where the most vulnerable part is in the region of the brazing at the flange. The brazing material might be the first part to yield on the sudden application of an excessive load, or the pipe itself immediately behind the flange may have been damaged by local over-heating during the brazing on of the flange, and prove the weakest part of the structure. The best safeguard for copper pipes of every description is periodical annealing followed by the application of an hydraulic test to twice the working pressure. This process generally locates any weakness developing in a pipe. A bad failure under the water test demands renewal of the length of pipe; a minor leak can usually be repaired by rebrazing or renewing the flange or by brazing on a patch, according as the leak shows at the flange or in the longitudinal joint. The Board of Trade and the classification societies require all copper main and large auxiliary steam pipes on vessels under their survey to be removed from place and treated in the above manner at intervals of not more than four years. If this practice is strictly adhered to, there is no reason why copper steam pipes for the above-mentioned pressures should not be as immune from accident as any other type.

Practically all large steamships now under construction are being fitted with steel or iron main steam pipes. Where superheat is in use these materials are, of course, essential. Wrought-iron pipes are always, and mild steel pipes sometimes, made from strips with longitudinal lap welds. The great majority of high-pressure main steam pipes are, however, now made from solid-drawn mild steel tubes; when the diameter is too large for manufacture in this way riveted seams are usually resorted to. Up to moderate sizes, the flanges are screwed on and the ends of the pipe then expanded therein. Large sizes of pipes require the flanges to be riveted on. A mild steel of low tensile strength, say between 23 and 28 tons per square inch, with a correspondingly increased percentage elongation, makes the best steam pipes from all points of view—for bending to shape and for more efficient expanding of the pipe in the slightly harder steel flange during the manufacture, as well as for the subsequent automatic straining set up in the pipe line when under working conditions. Solid-drawn steel tubes sometimes come from the mills not quite uniform throughout in thickness; this fault has to be guarded against when tubes are being selected for high-pressure steam pipes; eccentric screwing of the end of an otherwise concentric tube is another possible source of weakness; tubes showing laminations are also outside the zone of high-pressure steam pipe materials. So far as we are aware, there has never been an accident on board ship due to the failure of a solid-drawn steel steam pipe.

Steel pipes, however, being much more rigid than copper ones, demand more consideration for expansion and contraction. When adequate bends cannot be inserted in the pipe line expansion joints should be fitted. If these expansion joints are to carry out their useful function they require a fair amount of attention. In a steel or iron steam pipe line when the same joints repeatedly blow out, provided the adjoining flanges are parallel and close with the bolts removed, this is usually a sign that the pipe line is too rigid. The pipes when heated up have adjusted themselves to a certain position. On steam being shut off they contract and, not being provided with adequate flexibility, a leaking joint is a likely sequence to the next application of steam pressure. In such cases, expansion joints, if fitted, should be examined. If found seized up, they should be overhauled and

re-packed with self-lubricating packing at the first opportunity. A pipe line well supported in the region of an expansion joint of the usual telescopic type ensures better working conditions for the latter as any movement must then take place in the intended longitudinal direction.

A large hoop-shaped copper pipe bend, kept if possible in a horizontal plane, is often fitted in lieu of one length of steel or wrought-iron pipe in an otherwise too rigid run of piping. When this is fitted the non-conducting lagging should be kept well clear of the flanges for convenience of frequent examination of these parts. The annealing and testing, as already mentioned in connection with complete copper pipe lines, is then doubly necessary in this case where a comparatively flexible and short length is taking up the working movements of the whole pipe line.—"The Marine Engineer and Naval Architect," December, 1923.

THE MARINE ENGINEERING SITUATION.

Lloyd's Register Shipbuilding Returns for the quarter ended September 30, issued recently, show that the tonnage of vessels under construction in the United Kingdom during that quarter is 67,000 tons less than at the end of the preceding quarter. In Table I, on page 127, we show for each of the principal shipbuilding countries the number, and the tonnage, of steam and motor vessels upon which work has been commenced during the past quarter. It will be seen that in Great Britain and Ireland there were laid down twenty-three steamships with a total gross tonnage of 71,280, *i.e.* an average of 3,099 tons per ship; motor ships are given as five, with a total gross tonnage of 40,180, *i.e.* an average of 8,036 tons per ship, or in other words, the average motor ship figure is more than twice the average steamship figure. This would appear to suggest that the motor ship although not showing an ascendancy in numbers, shows a distinct increase in individual tonnage; this is, however, accounted for by the fact that some passenger liners of comparatively large tonnage have been laid down. The number of motor ships laid down has decreased from eighteen to five since the last quarter, but the average has increased from about 5,000 tons to about 8,000 tons during the quarter. A list of average gross tonnages for motor ships commenced in the United Kingdom for the past four quarters shows figures as follows, commencing with the quarter just finished:—8,036 tons, 5,028.6 tons, 4,802.4 tons, 6,052 tons. This, while showing a decrease after the last quarter of 1922, shows a steady rise for each of the three quarters of this year.

In Denmark work has been commenced on two vessels with an aggregate gross tonnage of 4,775 tons as against one vessel last quarter with practically the same gross tonnage, thus indicating an increase in numbers but not in size.

Sweden shows a blank in her motorship returns, but this is the case also with her steamers. Japan, it would seem, has at last determined to consider the motor ship seriously, and during the past quarter she has laid down one vessel with a gross tonnage of 4,600 tons, the engines for which we believe are to be constructed in this country. There is again no information regarding the vessels commenced in Germany, so that it is impossible to determine to what extent she is taking up motor tonnage. The American returns show up rather surprisingly when compared with the figures for the quarter ending June 30. Only one ship has been commenced during the last quarter, and this is a steamer with the almost negligible tonnage of 170. Table II, which is shown on page 128, summarizes the total tonnage for all countries upon which work has commenced, steam

TABLE I.—SHOWING STEAM AND MOTOR SHIP TONNAGE COMMENCED DURING QUARTERS ENDING :—

Country.	Sept. 30, 1923.		June 30, 1923.		March 31, 1923.		Dec. 31, 1922.	
	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.
United Kingdom—								
Steamers	23	71,280	52	148,123	110	303,949	64	199,307
Motor Vessels	5	40,180	18	90,515	10	48.024	5	30,260
Denmark—								
Steamers	6	8,732	3	5,305	8	11,916	2	2,060
Motor Vessels	2	4,775	1	4,350	1	107	4	10,610
France—								
Steamers	4	4,210	4	9,730	9	48,830	2	14,800
Motor Vessels	—	—	—	—	—	—	9	3,900
Holland—								
Steamers	1	1,250	—	—	2	2,900	5	4,400
Motor Vessels	3	22,500	—	—	2	360	—	—
Italy—								
Steamers	4	18,400	—	—	—	—	2	7,300
Motor Vessels	—	—	—	—	—	—	—	—
Japan—								
Steamers	7	10,865	11	11,350	5	5,530	12	12,234
Motor Vessels	1	4,600	—	—	—	—	—	—
Norway—								
Steamers	3	380	10	6,727	10	5,145	3	4,744
Motor Vessels	—	—	—	—	4	725	—	—
Sweden—								
Steamers	—	—	1	600	2	2,050	1	1,450
Motor Vessels	—	—	2	6,000	3	11,300	—	—
America—			6					
Steamers	1	170	3	16,800	18	50,756	10	42,350
Motor Vessels	—	—		6,000	7	18,200	1	1,000

and motor, and shows also the motor ship percentage of the total. This latter, it will be noticed, is maintaining its upward tendency, and for the last quarter shows 34.8 per cent against 30.4 per cent for the preceding quarter. In the notes which are attached to the official returns, mention

TABLE II.—SHOWING PERCENTAGE OF MOTOR SHIPS COMMENCED OF TOTAL TONNAGE FOR ALL COUNTRIES.

	Quarter ending—			
	Dec. 31, 1922.	Mar. 31, 1923.	June 30, 1923.	Sept. 30, 1923.
	Tons.	Tons.	Tons.	Tons.
Steam	291,995	443,716	202,515	134,997
Motor	41,870	79,616	107,015	72,160
Motor ship percentage of total	12·5	15·2	30·4	34·8

is made of the fact that the total motor ship tonnage now building in the world amounts to 460,868 tons, a figure which is equal to over 24¼ per cent of the steam tonnage under construction, "showing," the note adds, "the continued development which is taking place in the adoption of this system of propulsion." The returns show that the total tonnage under construction in the world for the carriage of oil in bulk, over 1,000 tons, amounts to twenty-eight vessels, both steam and motor ships, with a total gross tonnage of 178,590 tons.—"The Marine Engineer and Naval Architect," November, 1923.

THE LARGEST MOTOR SHIP IN THE WORLD.

UNION CASTLE LINER OF 20,000 TONS GROSS AND 20,000 I.H.P. MACHINERY.

Some months ago we stated that it was not unlikely that the Union Castle Steamship Co. would order a motor liner somewhat similar to the *Arundel Castle* fitted with Diesel machinery. This order was actually placed last month, and the vessel will be built by Harland and Wolff, Ltd., at Belfast.

She will be the biggest and highest-powered motor vessel yet constructed, having a gross tonnage of 20,000, with a length of 630 feet, and a beam of 73 feet, the depth being 46 feet.

The machinery will be built by Harland and Wolff, and will be of similar type to the double-acting four-cycle plant developed by Messrs. Burmeister and Wain, of which a full description was published in our last issue. We understand that the cylinder dimensions will also be identical—namely, a bore and stroke of 840 mm. and 1,500 mm., respectively, with a speed of 125 R.P.M.

The Burmeister and Wain-built engines, however, develop 6,750 B.H.P. in six cylinders, and do not drive their own air compressors. Those constructed by Harland and Wolff have eight cylinders, and drive twin three-stage air compressors, so that the power developed will be 10,000 I.H.P. for each engine, or between 7,000 B.H.P. and 8,000 B.H.P.

Electricity will be used for all purposes in the ship, even for heating and cooking, and there will be four Diesel-driven generators installed in a separate compartment forward of the main engine-room.

The speed of the *Arundel Castle* is 18 knots, and presumably that of the new vessel will be approximately the same, whilst the dimensions are almost identical. The South African run is one on which the motor liner will show to special advantage, since the journey from Southhampton to Cape Town takes about 18 days, while the fact that the motor ship will only require about one quarter the weight of fuel, and that this can be carried in double bottoms, is an enormous advantage. It will probably be found that the total daily consumption will not exceed 60 to 70 tons at full speed, so that the new vessel could easily carry a sufficient quantity of fuel for the trip without rebunkering.—"The Motor Ship," December, 1923.

ADMIRAL BENSON'S PROPOSALS.

Rear-Admiral W. S. Benson, formerly chairman of the United States Shipping Board, recently outlined a plan which he urged should be taken by the Government in connection with the large fleet of vessels which they now possess. He suggests the following measures:—

"First, extension of the benefits of Section 11 of the Merchant Marine Act of 1920 (construction loan fund) to the conversion of American flag steamships of the best and most efficient type into reliable and economical motor ships.

"Should Congress approve such modification, the Board can then loan two-thirds of the conversion at a reasonable rate of interest, with payments extending over a period of years.

"Secondly, the adoption of a suitable policy of standardization for the ultimate object of reducing production costs of Diesel machinery and auxiliaries. Considerable study has already been given to this subject and further progress is anticipated.

"Thirdly, the conversion of a number of the Board's own vessels to serve the long-distance routes, for the two-fold purpose of reducing cost of operation and to give impetus to domestic Diesel construction.—"The Motor Ship," December, 1923.

RIGHTING A CAPSIZED SHIP.

Successful Righting and Setting Afloat of the Brazilian Steamship "Avare" in Hamburg Harbor.

By Dr. M. Probst, Marine Engineer.

When the Brazilian passenger steamer *Avare* was leaving the dock last year with double bottom tanks only partially filled, she capsized, for want of sufficient stability, and caused the loss of 39 human lives. In its wrecked position, the ship, which was lying between two piers, was a big obstacle to shipping. A quick salvaging operation, therefore, was demanded in the interests both of the owners and of the Harbor Authorities.

The vessel, with a tonnage of 8,227, has a length of 438 feet, a breadth of 56 feet, and a depth of 38 feet. She was formerly owned by the North German Lloyd under the name *Sierra Salvada;* but by the Peace Treaty

of Versailles she was transferred to the Brazilian Government. The Vulcan Works of Hamburg undertook the salvaging work, their large shipbuilding yards being situated very near to the place of the accident.

The distance between ship and land being only 300 feet, the salvaging was practically a simple matter, the method adopted having often been practiced on smaller boats, with some greater complications also on the German liner *Gneisenau*, sunk 1914 and salvaged 1917 in the River Schelde near Antwerp, and on the American passenger ship *St. Paul*, which capsized and was salvaged in New York Harbor. This was done by raising about 12 triangular trestles on the port side of the hull, which was strengthened by longitudinal girders. Then these trestles were connected by means of tackles to fixed points on the pier, consisting of driven piles. The tackles were then pulled by steam winches until the ship was righted. After being righted the ship could be ballasted, refloated and towed to the dock.

In spite of the simplicity of this method, extensive preparations were required on the part of the shipyard and her contractors. Trestles 35 feet high were constructed, riveted and erected on board by means of the Vulcan's large floating crane. As the structural material for this work could be taken from the yard's stock, the whole work was finished within a few weeks. All the trestles were connected by horizontals and diagonals, forming a rigid framework.

At the same time large piles were driven into the sand bottom of the quay shed by means of two steam drivers used for building work. Altogether, 132 piles of 35 feet length and 18 inches diameter were required. They were driven in groups of four or six, forming 30 fixed points for the 30 tackles, each of 40 or 60 tons pulling power. The total pulling power was estimated at 1,320 tons.

Within the short time at disposal it was rather difficult to assemble the necessary lengths of steel ropes, the whole length of which had to be 20,000 yards. With less difficulty the required steam winches were produced; for on account of the restricted space disposable in the shed no more than 22 winches could be placed there. There were also eight floating winches, each with its own boiler on board. These were moved to the quay below the main tackles.

It was also an important factor to have an adequate supply of steam for the winches on land. Therefore, two large tugs containing 10,500 square feet of heating surface were disposed as close as possible to the main winches, and from the tugs steam pipes of six inches diameter, connected by flexible hoses, were conducted to the battery of winches. Similarly, exhaust pipes were arranged to parallel to the supply pipes, exhausting out of the shed upwards into the open air.

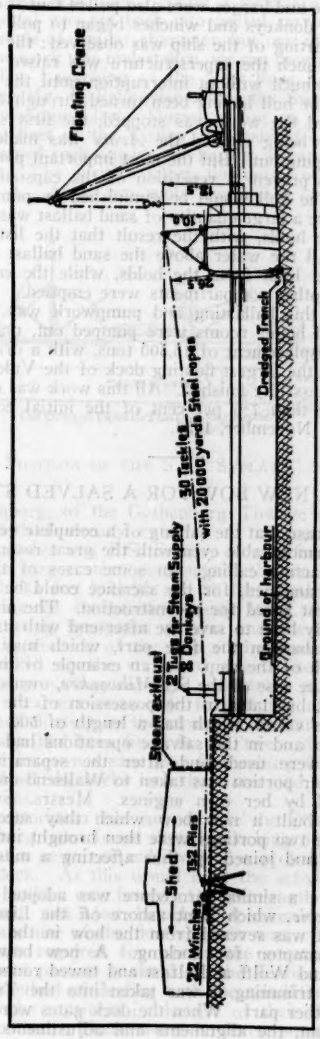
In spite of the difficulty of working under water, the holds of the ship below the third deck were made nearly watertight and partially sounded by powerful pumps on board of the salvage barges. The weight to be lifted was by this means reduced. A further diminishing of the required righting movement was gained by dredging a trench below the starboard bilge keel, so that the center of rotation was displaced about seven feet nearer to the center of gravity.

As a considerable reserve of lifting power for the first and hardest period of lifting, four salvage barges and the floating crane of the Vulcan shipyard were moved to the deck side of the capsized vessel. These exerted a lift of 800 tons. The total turning moment, realized with the described means, was 135,000 foot tons.

Near the middle of August all the preparations were finished, and the navigable water, hitherto used by shipping, was shut off, preparatory to stretching the steel ropes of the tackles between ship and land. The valves on the steam pipes leading from the tugs were opened, the winches tested, and the steel ropes gradually pulled taut. On the morning of August 16

THE CAPSIZED "AVARE," WITH 12 STEEL TRESTLES ERECTED UPON HER SIDE FOR ATTACHMENT OF THE PULLING CABLES.

THE SHIP PARTLY RIGHTED, READY FOR THE FINAL PUMPING AND FLOATING.



THIS SHOWS, LEFT TO RIGHT, THE PULLING WINCHES IN THE PIER SHED, THE CABLES, THE CAPSIZED SHIP WITH THE STEEL TRESTLES ERECTED ON HER SIDE, AND THE FLOATING CRANE.

the holds of the ship were drained as much as possible by pumping; the lifting tackles of crane and barges were also pulled taut; and then, on a blast signal, all the barges, donkeys and winches began to pull at full power. In a short time a small lifting of the ship was observed; the winches continued turning; and inch by inch the superstructure was raised out of the water. The turning was continued without interruption until the inclination of the ship was 18 degrees, the hull having been turned through 72 degrees. When this angle was reached the work was stopped, the first stage of salvaging being finished. After being righted the *Avare* was made fully watertight and prepared for pumping out. But the most important point was the stabilization of the ship, to prevent a repetition of the capsizing at the moment when the weight of the hull would be diminished by pumping to the point of flotation. Therefore a large quantity of sand ballast was brought on board and distributed in the holds, with the result that the list of the ship was further decreased. All the water above the sand ballast could now be removed by pumping, at least from the holds, while the engine rooms were left flooded until the other compartments were emptied.

On September 7th this ballasting and pumpwork was finished and ultimately the engine and boiler rooms were pumped out, until the ship began to get afloat. On a displacement of 15,500 tons, with a draft of 30 feet, the *Avare* was towed into the largest floating dock of the Vulcan Works, where the salvaging was successfully finished. All this work was done in ten weeks, at a cost of no more than 7½ per cent of the initial cost of the ship.—"Scientific American," November, 1923.

LAUNCHING A NEW BOW FOR A SALVED STEAMSHIP.

It is sometimes the case that the salving of a complete vessel presents difficulties which are insurmountable even with the great resource of the skilled exponents of that exacting calling. In some cases of that character the entire vessel is not abandoned, for the sacrifice could be limited to a part of the ship and the rest saved for reconstruction. The aim in an endeavor of this type has usually been to save the after-end with its valuable propulsion machinery and abandon the fore part, which may extend to about one-third of the length of the ship. As an example of this character mention may be made of the case of the SS. *Milwaukee*, owned originally by the Elder Dempster Line, but later in the possession of the Canadian Pacific Company. In 1899 this vessel, which had a length of 500 feet, was wrecked on the Aberdeen coast and in the salvage operations had to be cut in two. Dynamite catridges were used, and after the separation the bow was abandoned but the after portion was taken to Wallsend-on-Tyne, stern first, by tugs, but assisted by her own engines. Messrs. Swan, Hunter and Wigham Richardson built a new bow which they successfully launched from their yard. The two portions were then brought into proper relationship in the dry dock and joined up, thus affecting a most successful piece of repair work.

Another case where a similar procedure was adopted was that of the White Star liner *Suevic*, which went ashore off the Lizard on March 17, 1907. The after part was severed from the bow in the salvage work and was towed to Southampton for docking. A new bow was constructed by Messrs. Harland and Wolff at Belfast and towed round to Southampton. After unloading and trimming it was taken into the Trafalgar dock for association with the other part. When the dock gates were closed the water was partly pumped out, the alignments and adjustments were then made, and heavy timber guides were used to ensure that the correct position was taken up by the bow. When drawn into place the two parts were held

together by stretchers while two frames were built in and the work on the bulkheads, decks, &c., was done. Again a successful achievement was recorded and the vessel was put back into useful service.

Of a third example of similar character, but one for which a fair amount of preliminary test work was undertaken, we can now give particulars, thanks to a paper on "The Launching of the New Fore End for S.S. *Sydland*," which was read by Mr. A. Palmquist before the Swedish Naval Architects, at Gothenburg, in August last. During a fog on December 20, 1921, the vessel, one of the fleet of the Tirfing Steamship Company of Gothenburg, ran upon a submerged rock outside the harbor when on her first return visit to her home port. The position which the vessel occupied on the rocks is indicated in Fig. 1. As it was quite impossible to salve the whole ship,

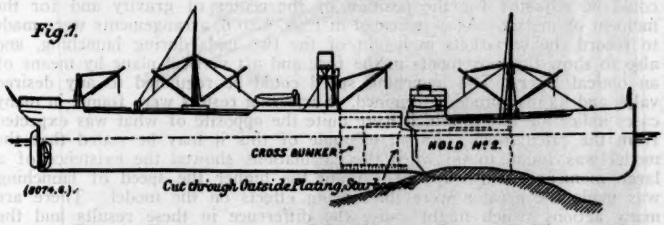


FIG. 1.—POSITION OF THE S.S. "SYDLAND" ON THE ROCKS.

Captain C. Malmborg, of the Gothenburg Towage and Salvage Company, suggested the method already referred to in connection with the cases of the S.S. *Milwaukee* and S.S. *Suevic*, of sacrificing the fore end in an effort to save the larger stern portion and the machinery. The ship was 420 feet in length, 55 feet breadth and 37 feet depth from the shelter deck. It was, at the time of the accident, fully laden, the deadweight tonnage being 10,850. Cutting by means of gas and the use of dynamite were resorted to for the division of the ship at the place where the plating had already been cracked on the starboard side. The last ties were broken by the heavy seas prevailing during a southernly gale on January 4, 1922, and the salvage steamers were able to pull the after part clear of the rocks. It remained floating as the strong cross-bunker bulkhead was intact and temporary ones had been fitted in the 'tween decks. It was then able to proceed under its own steam into Gothenburg Harbor. Meantime the fore end had slid off the rocks into the water and actually lies at a depth of about 11 fathoms.

The work of restoration was entrusted to the Eriksberg Mek. Verkstads A.-B. of Gothenburg, who found that the docking of the salved portion for the building on of a new fore end involved a prolonged occupation of their largest floating dock. As this would limit the activity of the firm unduly, it was decided to build a new bow of 143 feet length on one of the building berths of the yard, and after launching it connect the portions together in dry dock. Some use of the floating dock was, of course, necessary, for measurements were required for use in the construction of the forward part, and the salved portion is shown in the floating dock for this purpose in Fig. 2. This method of dealing with the rebuilding of the ship not only gave freedom to the repairers in the use of their floating docks, but was in addition economical. There were, however, some difficulties which demanded consideration. They were those of launching and the adjustment of the two portions in the dry dock. The structure was different in so

many ways from an ordinary vessel that it was thought advisable to conduct a series of tests beforehand with a model. Calculations had shown that it was impossible to launch the structure bow first because of the excessive tipping actions that would operate. Again, if the usual arrangement of concentrating as much weight as possible at the forward part to reduce the tipping actions was resorted to, a considerable dipping action was to be anticipated as the vessel left the ways. As this might put the structure in an unstable position, tests with a scale model were thought to be imperative.

A complete model of the vessel, ways and basin, was made to a scale of one-thirtieth. Drawings of the arrangement used are given in Figs. 4 to 6, the results obtained are shown in the graphs in Fig. 7. The model was made of thin wood, and being lighter than the correct relative weight could be adjusted for the position of the center of gravity and for the moment of inertia. As is indicated in Figs. 4 to 6, arrangements were made to record the variations in height of the two ends during launching, and also to show the movements in the fore and aft vertical plane by means of an optical lever. The launching speed could be regulated to any desired value and its magnitude determined. Surprising results were found, in many cases indicating effects which were quite the opposite of what was expected from the calculations. As an example of this it may be stated that the model was found to tip when the calculations showed the existence of a large moment against tipping. Again the higher the speed of launching was made the greater were the tipping effects on the model. There are many actions which might cause the difference in these results and the magnitude of their influence, with such an unusual shape of structure, not being completely understood, could not be properly allowed for in the calculations. One thing that is certain is that preliminary experimental work with models when unusual and irregular forms have to be dealt with, is more informative than the most careful treatment by calculations, for there is always uncertainty as to all the possible actions being allowed for.

In the problem presented by the case of the fore end of S.S. *Sydland* further experiments with the model showed that the difficulties could be overcome by building a temporary wedge wall of timber at the after end and keeping the launching weight down to a minimum. Tests showed no tipping actions with the model thus changed, even when the test speeds were equivalent to between 10 and 12 knots. The actual launching was performed in the way indicated as advisable by the tests, and was completely successful. The shelter deck plating and the shell plating of the 'tween decks was not fitted before launching, as this reduction had been allowed for in keeping down the center of gravity in the model experiments. The anticipated difficulties in docking the two portions, obtaining correct alignment and connecting them together were not experienced and the vessel thus rebuilt, is again afloat.—"Engineering," November 9, 1923.

THE "ROCKET" OIL SEPARATOR.

The great development that has taken place in recent years in use of oil fuel for marine propulsion has led to much trouble from the discharge of oily water from the tanks of ships in harbor. As the fuel oil is consumed at sea, the tanks are filled with water to preserve the stability and trim of the ship, and it is mainly from the discharge of this water in port preparatory to the operation of refueling, that the trouble arises. Objections raised to the presence of the oil which collects in considerable quantities on the foreshore in the neighborhood of large ports led to the passage of the "Oil in Navigable Waters Act," which became operative on January 1 of this year. By this Act, ship masters discharging oily water within certain

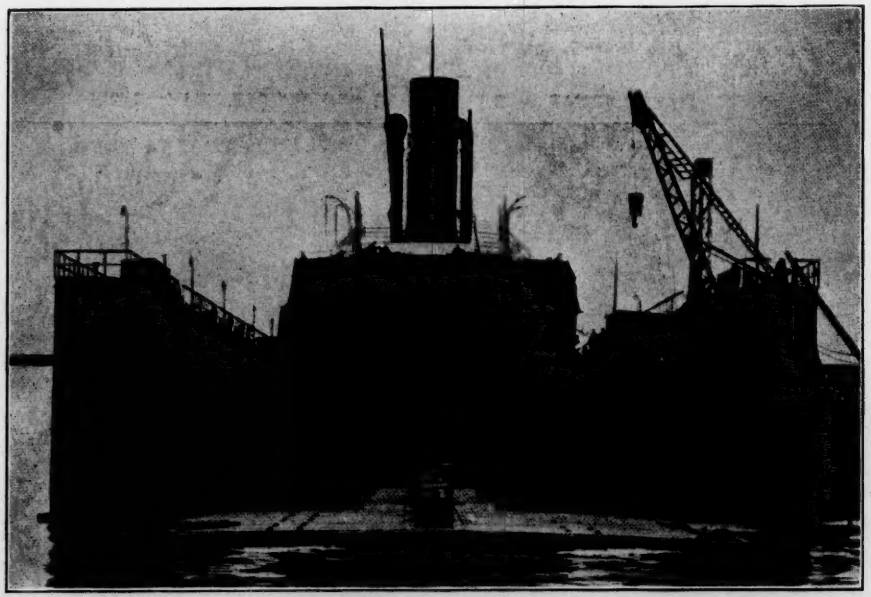


FIG. 2.—AFTER END OF THE SALVED S.S. "SYDLAND" IN FLOATING DOCK FOR MEASUREMENT.

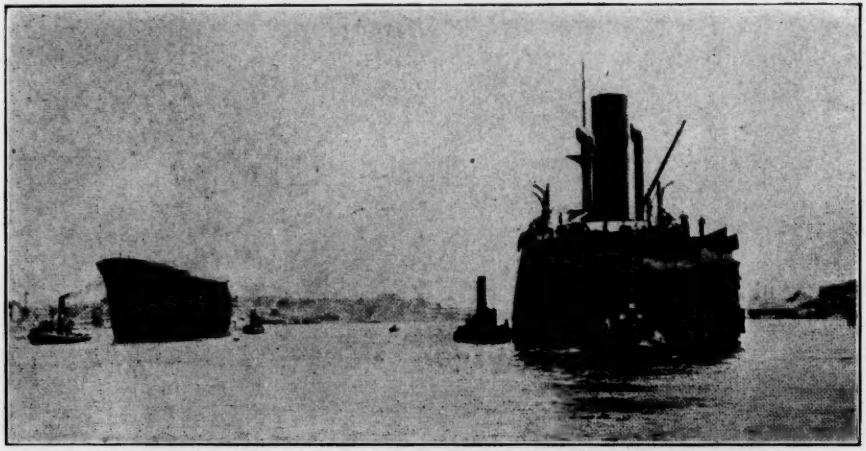
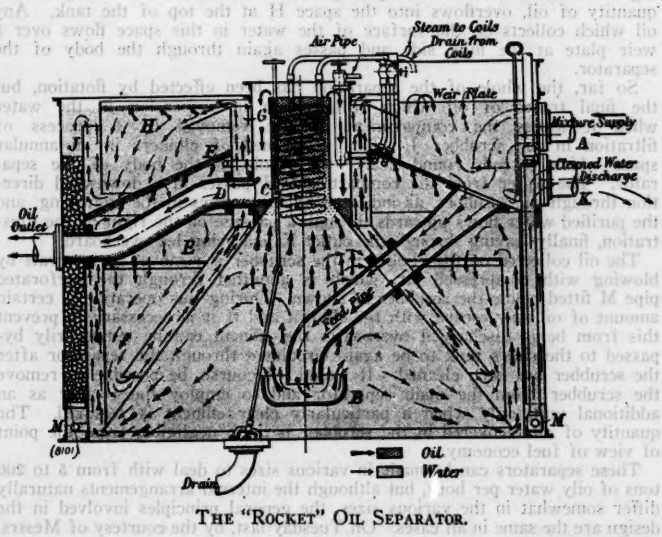


FIG. 3.—AFTER END AND NEW BOW OF THE S.S. "SYDLAND" BEING TOWED TO DRY DOCK.

prescribed limits are liable to heavy penalties, and a ship in harbor must therefore either discharge the water into a barge alongside or through a pipe line to the shore, or else proceed to sea for the purpose. In any case a considerable quantity of oil is lost to the shipowner, and even if it is discharged at sea outside the prescribed limits, much of it drifts back by the action of the wind and tide, creating a nuisance as before.

To recover the oil, and at the same time to avoid the troubles which would arise from the discharge of oily water in port, a device known as the "Rocket" oil separator has been designed by Mr. H. M. Alexander, Assoc. M. Inst. C. E. This device, which is being handled by Messrs. General Oil Conservancy, Limited, 36, St. James Street, S. W. 1, can be installed on the ship for the purpose of recovering the oil and discharging only clear water overboard. It can also, of course, be installed on shore by harbor authorities and others, for treating the oily discharge from ships in port, but the advantage of installing it on the ship is that it can if necessary be used at sea (where at present no restrictions are placed upon the nature of the effluent) for the recovery of oil which would otherwise be wasted. The plant is claimed to occupy but little space, to be automatic in action, requiring very little attention, while it contains no moving parts.



THE "ROCKET" OIL SEPARATOR.

The principle of the apparatus is illustrated in the sketch, which shows the separator in section. As will be seen, it consists of a cylindrical tank containing a number of conical and cylindrical baffle plates between which the oil and water flows in the directions indicated by the arrows. The mixed oil and water delivered by the ship's pumps enters through the pipe A on the right of the illustration, passing first into a compartment formed in the upper part of the tank. From this it flows over a weir plate (the object of which is to maintain a constant level and to permit any entrained air to escape) through the inclined feed pipe shown and into a central

conical chamber B. In this chamber, the velocity of the mixture is reduced sufficiently to allow the greater part of the oil to rise into the cylinder formed on the apex of the cone. This cylinder contains a steam coil which heats the oil and water to facilitate separation and to reduce the viscosity of the oil. As the latter collects here, it flows over the upper edge of the cylinder, which is slightly higher than the level of the weir plate, into the annular space C and out through the pipe D, which is connected to the ship's fuel tanks. More than 90 per cent of the oil contained in the mixture supplied to the separator is removed in this way.

The water with the oil which still remains mixed with it, passes out under the bottom edge of the cone B, up through an annular passage into the chamber E, the upper part of which is closed by a conical plate F. On the latter most of the remaining oil collects and travels up towards the apex of the cone where it is heated by the steam pipe shown in the engraving. This oil flows into the outlet through a horizontal pipe controlled by the valve shown, and the same fitting provides a means for the escape of any air which may collect in the upper part of the chamber E.

Water from the latter first passes downwards and then travels up through the passage G, formed by a conical plate mounted coaxially with that forming the chamber B. From the passage G, the water, still containing a small quantity of oil, overflows into the space H at the top of the tank. Any oil which collects on the surface of the water in this space flows over a weir plate at the inlet side and passes again through the body of the separator.

So far, the whole of the separation has been effected by flotation, but the final traces of oil which still remain in suspension in the water when it leaves the compartment H are removed by a process of filtration in the scrubber J. This is formed of clinkers in an annular space which extends round nearly the whole of the body of the separator. The water from the compartment H passes in a downward direction through the scrubber, as indicated by the arrows in the engraving, and the purified water flows upwards through a passage on the right of the illustration, finally leaving through the outlet K and being led overboard.

The oil collected on the clinker in the scrubber is removed at intervals by blowing with compressed air, which is admitted through the perforated pipe M fitted below the scrubber as shown. During this operation, a certain amount of oil may escape with the effluent and if it is necessary to prevent this from being discharged overboard, the effluent can be temporarily bypassed to the ship's tank to be again circulated through the separator after the scrubber has been cleaned. It would, of course, be possible to remove the scrubber from the main separator and to employ the former as an additional unit, only when a particularly clear effluent is required. The quantity of oil recovered in the scrubber is quite negligible from the point of view of fuel economy.

These separators can be made in various sizes to deal with from 5 to 200 tons of oily water per hour, but although the internal arrangements naturally differ somewhat in the various sizes, the general principles involved in the design are the same in all cases. On Tuesday last, by the courtesy of Messrs. General Oil Conservancy, Limited, we had an opportunity of inspecting one of these plants installed for demonstration purposes at the Clover-Clayton Dry Docks of Messrs. H. and C. Grayson, Limited, at Birkenhead. The rated capacity of this plant is 100 tons per hour, and the tank used is 10 feet in diameter by 7 feet 3 inches in height. It was supplied with sea water mixed with from 12 to 15 per cent of a very low grade heavy oil, the specific gravity of which, we understand, was 1.003. The discharge was practically clear water, and no free oil could be detected by simple inspection in a test tube. The character of the discharge, however, obviously depends upon the rate at which the plant is worked, and this, we were informed, was at

its normal capacity of 100 tons per hour; if circumstances permit a less pure effluent to be discharged, the capacity of the plant could doubtless be greatly increased. A burner fired with the recovered oil was shown in operation.

In addition to the use of the separator for purifying the oily discharge from ships, the proprietors of the patents suggest that the apparatus could be employed in oil fields for separating any water which may be present in the oil as it comes from the wells. It must be pointed out, however, that the plant is only suitable for separating mechanical admixtures of oil and water; emulsions, or colloidal solutions, of oil and water could not be dealt with satisfactorily. Doubtless other industrial uses will be found for separators of similar design to that described, but, at the moment, its most important application appears to be that referred to at the opening of this article.—"Engineering," October 19, 1923.

ASSOCIATION NOTES.

ELECTION OF OFFICERS.

Votes cast by the membership for officers of the Society for 1924 were counted on December 27, 1923, and the following were declared elected:

President:

Captain J. T. Tompkins, U. S. Navy.

Secretary-Treasurer:

Commander Bryson Bruce, U. S. Navy.

Council:

Rear Admiral B. C. Bryan, U. S. Navy (Retired).
Captain Chauncey Shackford, U. S. Navy.
Captain H. L. Wyman, U. S. Navy.
Captain Q. B. Newman, U. S. Coast Guard.
Commander H. S. Howard (CC), U. S. Navy.
Mr. H. M. Southgate.
Mr. John F. Metten.

The President and Secretary-Treasurer are members of the Council ex-officio.

CHANGE IN SUBSCRIPTION PRICE.

By vote of the Council the subscription price of the JOURNAL has been increased to $6.00 for domestic and $6.40 for foreign delivery. Price for single numbers was placed at $1.50 for domestic and $1.60 for foreign delivery. This does not, of course, affect membership dues.

FINANCIAL STATEMENTS, 1923.

The following are the financial statements for the year 1923.

STATEMENT OF INCOME AND EXPENDITURE.

Expenditure.

Publication:			
Printing	$7,048.34		
Engraving	1,410.68		
Manuscript	906.00		
Drafting	7.25		
Postage	165.60		
Commission and Discount	204.28		
Exchange	.45		
		$9,742.60	
Salaries:			
Secretary-Treasurer	$1,500.00		
Clerk	1,000.00		
		2,500.00	
Banquet, 1923		262.10	
Membership Campaign		81.70	
General Expense		155.24	
Current Profit and Loss:			
Charged off for depreciation of Securities	$700.00		
Charged off for bad debts:			
Dues of Members	$378.75		
Advertising	37.50		
	416.25		
	$1,116.25		
Less credit for amount received from members for dues charged off to Profit and Loss, 1922	145.00		
		971.25	
			$13,712.89

Income.

Publication:			
Dues	$6,187.90		
Subscriptions	2,269.06		
Sales	934.79		
Advertisements	3,304.28		
		$12,696.03	
Interest on Investments		776.06	
			13,472.09
Net Loss			$240.80

NOTE: The net loss shown is due to the charging off of $700 for depreciation in value of securities, to carry them at market value as of 31 December, 1923. Except for this, a net gain of $459.20 would have been shown, which was the result of the operation of the business of the Society for the year 1923.

BALANCE STATEMENT.

Assets January 1, 1923			$17,708.68
Assets December 31, 1923:			
Cash in bank		$2,380.89	
Accounts Receivable:			
Advertisements	$1,663.66		
Dues	706.70		
Sales	193.91		
Subscriptions	90.05		
M. A. Libbey	5.00		
Akimoff Propeller Co.	15.00		
		2,674.32	
Investments (all Bonds):			
Army and Navy Club	$1,000.00		
Armour Co. of Del.	887.50		
Canadian Northern Ry.	1,115.00		
Hocking Valley R. R.	1,682.50		
International Mer. Marine	795.00		
New York Steam Corporation	927.50		
Ohio Power Co.	860.00		
Penna. Power & Light Co.	882.50		
Swift & Co.	917.50		
Washington Ry. & Elec. Co.	4,230.00		
		13,297.50	
Furniture		104.50	
		$18,457.21	
Liabilities:			
Dues paid in advance	$134.30		
Subscriptions in advance	855.03		
		989.33	
			17,467.88
Net Loss			$240.80

The above statements and accounts of the Society are being audited.

The following members have joined the Society since the publication of the last number of the JOURNAL.

NAVAL.

James, Leland F., Commander, U. S. Navy (Retired).
Johnston, Donald H., Ensign, U. S. Navy.
Kiernan, Joseph M., Lieutenant (CC), U. S. Navy.
Tarbuck, Raymond D., Lieutenant, U. S. Navy.
Thayer, Rufus G., Lieutenant, U. S. Navy.
White, Hugh L., Lieut. Commander, U. S. Navy.
Wilson, Edward P., Lieutenant, U. S. Navy.

CIVIL.

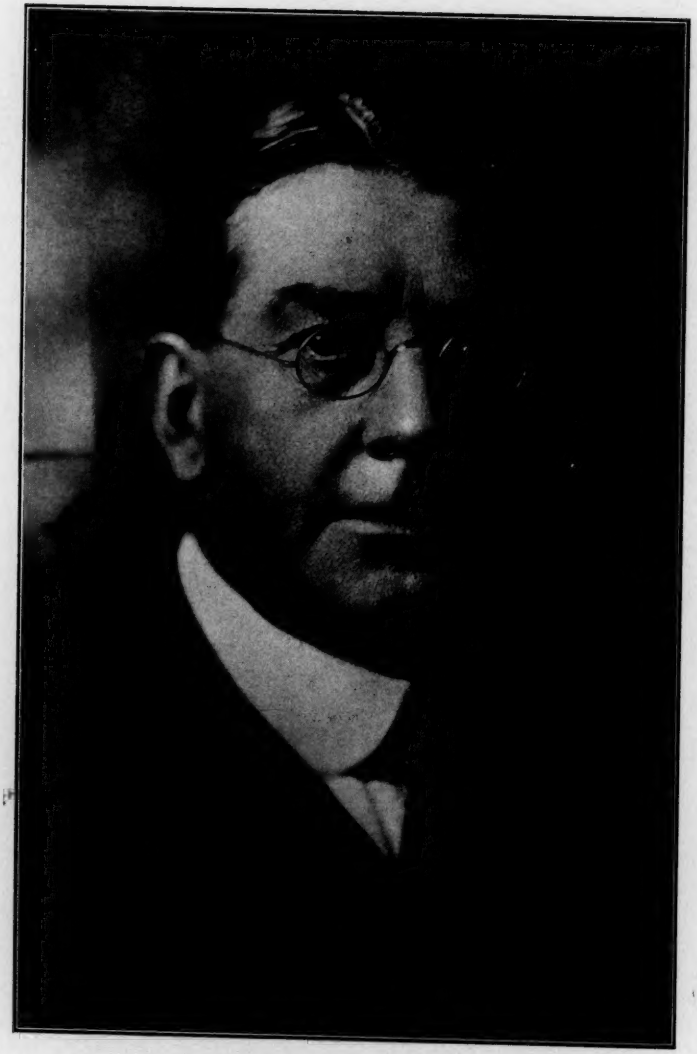
Haynes, Charles V., Vice-President, Hoffman Specialty Co., 2565 South 45th St., Philadelphia Pa.

ASSOCIATE.

Nones, Lynn W., Diamond Power Specialty Company, 90 West St., New York City.

The Annual Banquet of the Society will be held in the near future and ample notice will be sent to all members. Final arrangements have not been made but are being undertaken by the following committee:

Captain M. E. Reed, U. S. N., Chairman,
Commander H. S. Howard, (CC), U. S. N.
Commander W. A. Smead, U. S. N.
Commander O. L. Cox, U. S. N.
Commander H. Delano, U. S. N.
Commander Bryson Bruce, U. S. N.
Lt. Commander C. S. Root, U. S. C. G.
Mr. A. Conti.
Mr. B. P. Lamberton.



THE HONORABLE CURTIS D. WILBUR

SECRETARY OF THE NAVY

THE SECRETARY OF THE NAVY.

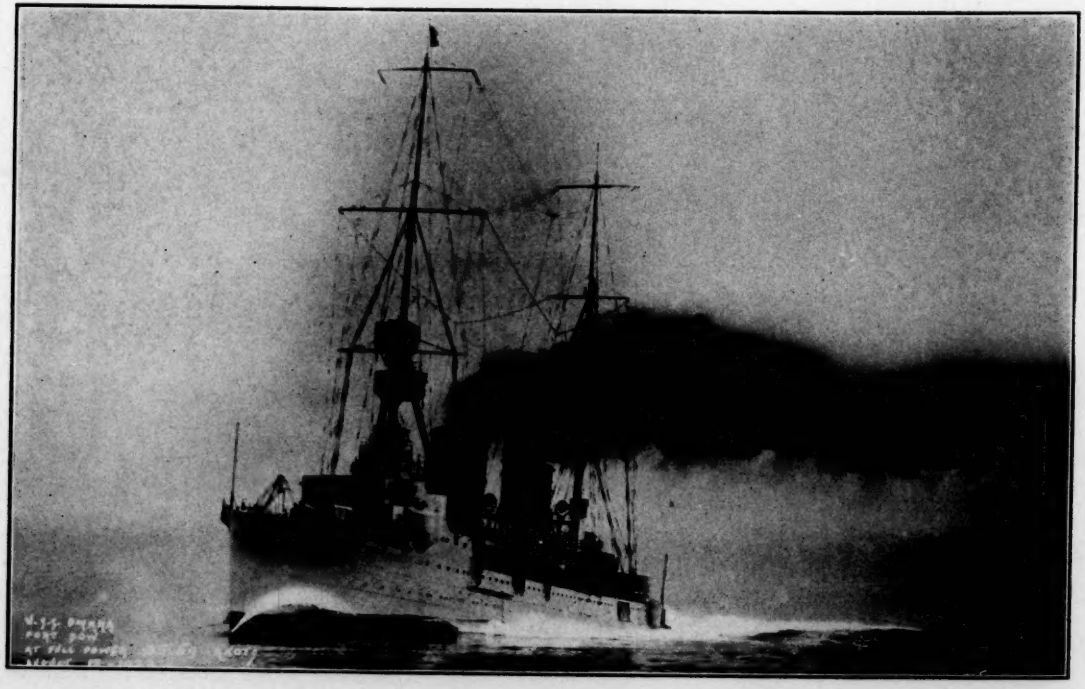
Judge Curtis D. Wilbur, Chief Justice of the Supreme Court of the State of California, took the oath of office and became Secretary of the Navy at San Francisco on March 19, 1924.

Secretary Wilbur was born in the State of Iowa, spent several years of his boyhood in the Territory of Dakota, and is fifty-seven years of age. In 1884 he was appointed a Midshipman at the U. S. Naval Academy and graduated four years later as a member of the class of 1888. Soon after graduation he resigned, took up his residence in California, began the study of law, and in 1890 was admitted to the bar. After a period of professional practice, he was elected a Judge of the Superior Court of Los Angeles County. He was appointed an Associate Justice of the Supreme Court of California in 1918, and elected Chief Justice in 1922.

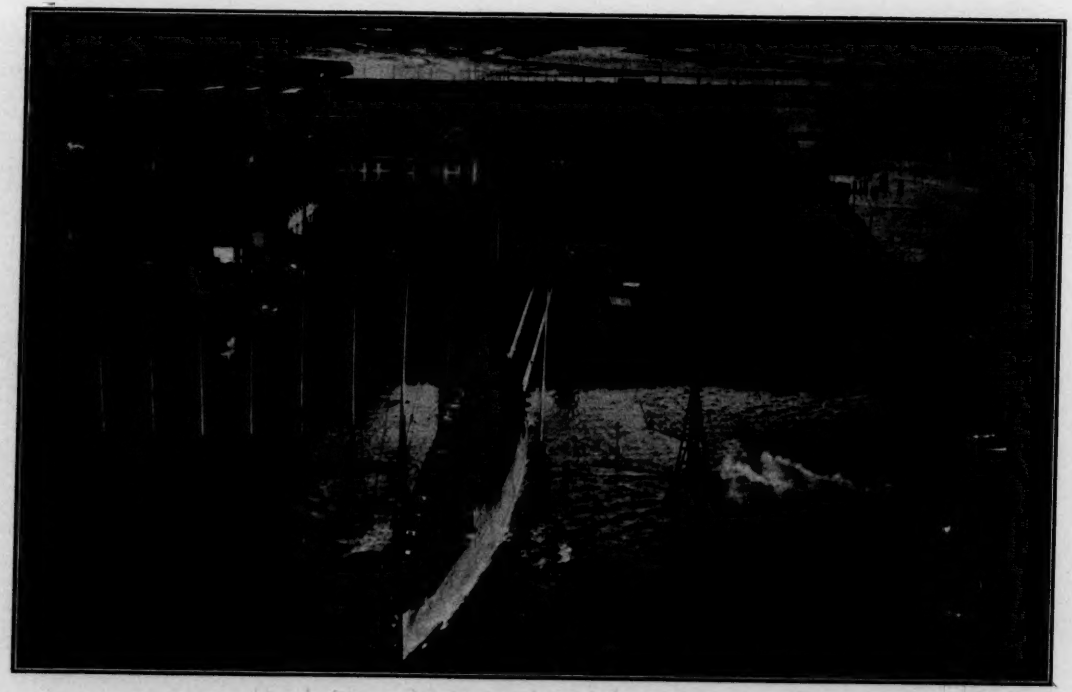
A San Francisco friend and neighbor of the Secretary of the Navy says: "Judge Wilbur is a man of commanding personality. He stands 6 feet 3 and his face and bearing carry the atmosphere of distinction. Intelligence, firmness and kindness are mirrored in the personality that commands the admiration of the public and the affection of those who have the fortune and the honor of his friendship."

In a recent communication to the President of the American Society of Naval Engineers, Secretary Wilbur expressed the following sentiment: "There have been extraordinary advances made in Engineering since the organization of the Society in 1888 and the Society of Naval Engineers has helped materially in this progress. In the late war the Engineer played a more conspicuous part than in any previous war. The importance to the Navy of a thorough grounding of its personnel in the knowledge of Naval Engineering is of ever increasing importance. Our ships must not only be manned by true Americans, but the personnel must understand thoroughly the practical handling of the material used."

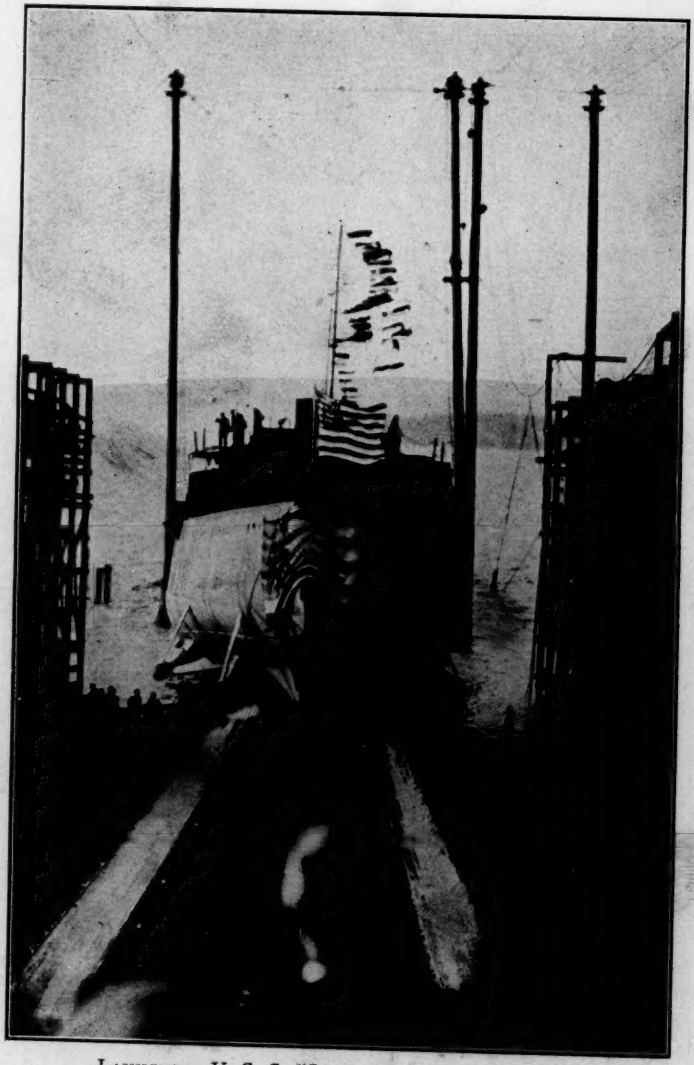
The Society extends to the Secretary its best wishes for the success of his administration of the Navy.



"U. S. S. Omaha."



LAUNCHING U. S. S. "OMAHA"—14 DECEMBER, 1920.



LAUNCHING U. S. S. "OMAHA"—14 DECEMBER, 1920.